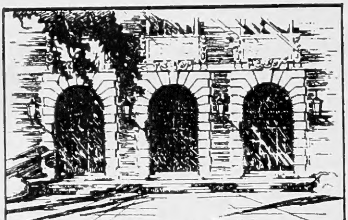

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THE AMERICAN GEOLOGIST

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Fifth International Congress Geologists Washington 1891

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Secretary's Office, 1330 F Street
Washington, D.C. 1891

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whose presence is an honor and an inspiration,

the members of the Fifth International Congress of Geologists assembled at Washington, A.D. 1891

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THE

AMERICAN GEOLOGIST

VOL. X. JULY, 1892. No. 1

[PALÆONTOLOGICAL NOTES FROM THE LABORATORY OF BUCHTEL COLLEGE.—No. 1.]

A NEW GIGANTIC PLACODERM FROM OHIO.

E. W. CLAYPOLE, Akron, O.

To the two genera and species of gigantic placoderms from the Cleveland shale described some years ago by Dr. Newberry in the Palæontology of Ohio, and in the Monograph on the fossil fishes of North America, published by the U. S. Geological Survey, has recently been added a third, equally formidable in its armour and scarcely less in size. This creature has been brought to light by the labors of Dr. Wm. Clark, of Berea, O., to whom geologists are also indebted for the material of great additions to our knowledge of some of the older forms of this remarkable ichthyic fauna. The new fish was found during the autumn of 1891, on the horizon and near the place which had yielded *Dinichthys* and *Titanichthys*.

Though resembling these, and especially the former, in general character, it yet exhibits at least one peculiar feature, in so far as yet known, which is sufficient at once to differentiate it from both its enormous contemporaries.

It is not at present possible to give any adequate account of the whole animal, as only a portion of it has yet been found. This preliminary note will therefore be limited to a description of the lower jaw and the teeth, which have been completely extricated from the matrix. A great part of the rest of the head still remains broken and bedded in the stone, and much time and great labor must be expended before we shall be in a position to fully describe this. No part of the body has been discovered.

GORGONICHTHYS CLARKI

EXPLANATION OF FIGURE.

Lower left mandible of *Gorgonichthys clarki* 25 inches long, showing groove worn by premaxillary, lateral process and denticles, and overlap of apparently two bones ankylosed together (mandibular and articular).
Premaxillary tooth, broken, point only.
Lateral tooth, fitting against lateral process of mandible.
Bone, exact nature uncertain, apparently a second lateral tooth in upper jaw.

Gorgonichthys, g. n., *Lower jaw or mandible.*

In general outline this resembles the corresponding bone of *Dinichthys*, from the largest species of which also it does not much differ in length, being in this—the only specimen yet known—25 inches long. There is the same upward curve at the hinder end, where also the bone thins away to a blade-like plate, the end of which was apparently received between two thin bony plates and afforded attachment for enormous muscles. The ankylosis of the two bones of which the jaw consists is firmer than in *Dinichthys*; that is to say, the jaw appears almost as if it consisted of only a single bone.

A little in front of the middle the mandible rises into a rounded tooth-like process an inch and a half high and occupying about four inches of its length. Each slope of this process is set with a row of five or six denticles or rather denticular serrations of the bone, standing at right angles to the surface. The resemblance of the fish in this point to *Dinichthys hertzeri* of the so-called Huron shale, is manifest. *D. terrelli*, however, of the Cleveland shale, has no such denticles.

Sinking in front of this process to its average level, the jaw again rises so as to form at its extremity a strong pointed tooth, closely resembling that of *Dinichthys*, roundly triangular in outline and having a total hight of five inches. The whole hight of this tooth from the lower edge of the jaw is nine inches.

Upper jaw.

Opposite to this tooth in the upper jaw is one corresponding to the great "premaxillary" of *Dinichthys* as described by Newberry. The specimen is somewhat imperfect, as its base (or upper part) has been broken off. So far as preserved it appears rather rounder in section and smaller than the great premaxillary of *Dinichthys*. As in that genus, however, it fitted close against the outer and hinder face of the great mandibular tooth, already described. This is proved by the groove which it has worn, and in which it was lying when found.

Behind this is the remarkable tooth which most perfectly characterizes the genus. Homologous to the cutting upper blade of the shears of *Dinichthys*, it evidently performed no similar function in the animal. Neither on it nor on the tooth-like process in the lower jaw above mentioned is there the slightest sign of wear or rubbing, such as is always visible on the jaws of *Dinichthys*. This tooth, which measures nine inches from the front to the back by seven inches in a vertical direction, is totally different from the rounded upper blade of *Dinichthys*, and much heavier. It terminates downwards in two blunt processes, whereof the foremost is the larger and the more prominent. Between these fitted the blunt projection of the lower jaw, though the signs of wear are not very conspicuous on either. Both show the usual hard, close and polished bony structure that marks the teeth of these fishes.

The mode of attachment of the upper teeth to the head is, as in the case of *Dinichthys*, not yet known, but their position and their evident adaptation to the lower jaw leave no doubt of their relationship. The whole outfit constitutes the most formidable dentary weapon yet known from this or perhaps from any horizon excepting possibly "*Carcharodon*" of the Eocene.

In addition to all the above there is another bone whose form, structure and position when found strongly indicate a close relationship to them. This has been represented in the figure, notwithstanding the uncertainty resulting from our inability at present to pronounce on its exact position. The blunt tubercle on its lower side shows all the usual marks of having been a denticular process, and it almost certainly lay close behind the great tooth last described. In default of certainty on this point, however, I prefer merely to indicate its probabilities, and to leave its determination for the future.

Found in the Cleveland shale, near Berea, O., by Dr. W. Clark, and named for him in acknowledgement of his patience and perseverance in exhuming and extricating it.*

THE STRATIGRAPHIC POSITION OF THE OGISHKE CONGLOMERATE OF NORTHEASTERN MINNESOTA.†

By ULY S. GRANT, Minneapolis.

In the region of Ogishke Muncie or Kingfisher lake (T. 65-6, Lake Co., Minnesota) is a marked conglomerate of considerable extent. It is well known to lake Superior geologists as the Ogishke conglomerate. It consists of pebbles of slates, graywackes and other clastic rocks, together with those of acid and basic eruptives, all embedded in a matrix of varying composition. Frequently this matrix is a dark or light colored argillaceous slate; at other times it resembles graywacke, and again it acquires a greenish color and approaches the chloritic schist of this region. But perhaps the most characteristic facies of the matrix is an impure quartzyte with angular and rounded grains of quartz; fragments of feldspar and hornblende are also present. The pebbles are of all sizes up to those over a foot in diameter. They are usually well rounded and are sometimes elongated in the direction of the strike. The rock has been more or less metamorphosed and in places the pebbles approach so near the matrix in character that the conglomeritic nature of the rock can be seen only on favorable weathered surfaces. The beds as a rule stand nearly vertical with a general northeasterly strike. However, it is often the case that no lamination can be discerned. The conglomerate, as far as known, fades off both along and across the strike, by simple loss of the pebbles, into the argillytes, green-

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*A short notice of this fossil was given at the meeting of the Geological Society of America at Columbus, O., in December, 1891, and the name was then first proposed.

†Published with the permission of the State Geologist of Minnesota. Read before the Minnesota Academy of Natural Sciences, June 14, 1892.

stones and graywackes to the north, which have been described as belonging to the Keewatin series. The exact geographical extent of the conglomerate is not fully known; it covers an area of nearly fifteen miles in the immediate vicinity of Ogishke Muncie lake, and has been seen to the north on the west shore of West Sea Gull lake and also in Ontario at the northwestern corner of Saganaga lake.* There has been no general agreement in regard to the relation of the Ogishke conglomerate to the surrounding rocks, and so it has seemed advisable, in the light of recently discovered facts bearing on this point, to give a brief outline of the opinions of the different geologists, who have worked in this region, concerning the position of the conglomerate; and also to state what is definitely known in regard to this question.

The first notice and discription of this conglomerate was given by Prof. N. H. Winchell in 1882.† In that description he applied no particular name to it, but since then it has been universally known among lake Superior geologists as the Ogishke Muncie or Ogishke conglomerate. At first he regarded it as part of the series of black slates (Animike) occurring on Gunflint lake and also of the series represented by the slaty argillytes of the vicinity of Knife lake and westward (Keewatin).‡ On further study, however, the correlation with the latter series was entirely abandoned, and until 1887 he regarded this conglomerate as the basal member of the Animike.§ [See end of this paper, paragraph on the use of the term Ogishke conglomerate.] In passing westward from the low dipping Animike of Gunflint lake to Ogishke Muncie lake, he says: "There is thus seen to be an undeniable gradation from the Animike into the [upper] conglomerate."‖ "The formation of horizontal slates of the vicinity of Gunflint lake and the international boundary is the same as the highly tilted slate and quartzyte formation that passes into the slaty conglomerate of the region of Ogishke Muncie lake."** He regards the Ogishke conglomerate as separ-

*A. C. Lawson, Lake Superior Stratigraphy, AMER. GEOLOGIST, vol. VII, page 324, May, 1891.

†Geol. and Nat. Hist. Survey of Minnesota, 10th (1881) Ann. Rept., p. 90.

‡Ibid., pp. 94-95.

§Ibid., 11th (1882) Ann. Rept., p. 170; 15th (1886) Ann. Rept., p. 381; 16th (1887) Ann. Rept., pp. 91, 97-98; 17th (1888) Ann. Rept., pp. 17, 20, 24, 47; AMER. GEOLOGIST, vol. I, pp. 11-14, Jan., 1888.

‖Geol. and Nat. Hist. Survey of Minn., 16th (1887) Ann. Rept., p. 91.

**Ibid., 17th (1888) Ann. Rept., p. 17.

ated from the Keewatin by an overlap unconformity,* and in correlating it with rocks of other parts of the lake Superior region he makes it the Minnesota equivalent of the lower slate conglomerate of the original Huronian,† thus putting it as the basal member of the original Huronian group.

Dr. Alexander Winchell, while admitting the possibility of the Ogishke conglomerate being part of the Animike,‡ still firmly believed it to be much older and an upper part of the Keewatin.§ "The *prima facie* evidence would make it part of the Keewatin system, conformable in structure and consecutive in history."‖ "Lithologically and stratigraphically, therefore, the identification [of the Ogishke conglomerate with the Keewatin] seems to be complete. * * * * * * On structural as well as lithological grounds the conglomerate seems to belong to the Keewatin series."** "Of this, however, I feel authorized to testify—the range of rocks lying within the field of my explorations in Minnesota, represents but *one* system."†† Later he said that he regarded the Ogishke conglomerate as a basal conglomerate;‡‡ he probably meant the basal member of a division of the Keewatin, as he certainly did not regard it as at the base of the Keewatin.

Prof. R. D. Irving thought that the Animike slates of Gunflint lake were once continuous with the folded slates of the region of Knife and Ogishke Muncie lakes, and that these latter were part of the Vermilion lake series of slates (Keewatin).§§ "His (Mr. W. M. Chauvenet's) work thus far, as also the results of our microscopic study of the sections gathered, has tended to show that the Knife lake schists are actually the Animike slates in a folded condition."‖‖ "The folded schists of Knife and King-

*Ibid., p. 68.

†The Animike black slates and quartzytes and the Ogishke conglomerate of Minnesota, the equivalents of the "original Huronian," AMER. GEOLOGIST, vol. I, pp. 11-14, Jan., 1888.

‡Geol. and Nat. Hist. Survey of Minn., 16th, (1887) Ann. Rept., pp. 349, 359.

§Ibid., 15th (1886) Ann. Rept., pp. 179, 194-195; 16th (1887) Ann. Rept., pp. 344-350, 359-360; Proceedings of A. A. A. S., XXXVIII, 1889.

‖16th (1887) Ann. Rept., Minn. Survey, p. 347.

**Ibid., p. 348.

††Ibid., 15th (1886) Ann. Rept., p. 195. At this time he had not seen the Animike.

‡‡Ibid., 18th (1889) Ann. Rept., p. 215; foot note.

§§U. S. Geol. Survey, 5th Ann. Rept., pp, 206-207.

‖‖Ibid., p. 207.

fisher (Ogishke Muncie) lakes belong evidently to the Vermilion lake band."*

Prof. C. R. Van Hise agrees with professor Irving in placing the Ogishke conglomerate as the equivalent of part of the Animike and in separating it from the Keewatin or that part of it which he terms the lower Vermilion, meaning by this the iron-bearing series of the Vermilion lake region.† He regards the conglomerate as a newer formation folded in with the older rocks of his lower Vermilion.‡

Dr. A. C. Lawson was the first to show conclusively that the Ogishke conglomerate is much older than the Animike and is separated from it by an enormous structural and time break.§

The opinions of the more noted geologists, who have recently worked in this region, having been given in outline, we will now proceed to a brief consideration of the relations of the Ogishke conglomerate to the rocks above and below it. This will be given under three heads:—(1) Relation of the Animike to the Saganaga granite, (2) Relation of the Ogishke conglomerate to the Saganaga granite, (3) Relation of the Ogishke conglomerate to the Keewatin.

Relation of the Animike to the Saganaga granite. On the north side of Gunflint lake the Animike is seen in contact with an underlying series of schists and granite. This granite is known as the Saganaga granite from the fact that the lake of that name lies almost wholly within its limits.‖ Now the almost horizontal Animike beds rest, in a practically undisturbed condition, on the truncated edges of these schists, which stand nearly vertical. And they (the Animike strata) also lie upon the granite perfectly unconformable, fitting into the hollows of the eroded surface. This unconformity of the Animike on the schists and granite has

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*Ibid., p. 208.

†An attempt to harmonize some apparently conflicting views of lake Superior stratigraphy, Amer. Jour. Sci., iii, vol. XLI, pp. 117-137, Feb., 1891.

‡Ibid., pp. 122, 124.

§Lake Superior stratigraphy, AMER. GEOLOGIST, vol. VII, pp. 320-327, May, 1891; especially p. 324.

‖For a fuller account of this granite area see:
A. Winchell, Geol. and Nat. Hist. Survey of Minn., 16th (1887) Ann. Rept., pp. 211-226, 330-334. H. V. Winchell, Geological age of the Saganaga syenite, Amer. Jour. Sci., iii, vol. XLI, pp. 386-390, May, 1891.

been described by N. H. Winchell,* Irving,† A. Winchell,‡ Van Hise§ and Lawson,|| and no one has ever questioned it. It is not necessary in this connection to discuss the age of the above mentioned vertical schists, concerning which some question has been raised,** but it is sufficient for the present purpose to consider only the age of the granite. From all our knowledge of granite it is never known to have been formed in or to have penetrated strata near the surface; we are thus forced to conclude that after this granite came into its present place and condition and before the Animike was deposited there must have been a long period of erosion, during which all the overlying surface rocks were removed. Thus there is an enormous difference in age between the Animike and the granite, the former being separated from the latter by a great unconformity and as long a period of erosion as is known in lake Superior geology.

Relation of the Ogishke conglomerate to the Saganaga granite. This granite has been traced in numerous exposures from Gunflint lake to the western side of Saganaga lake, and there can be no doubt that the granite which comes in contact with the Keewatin near the western side of the latter lake is the same as that underlying the Animike on the north side of Gunflint lake. On the northwestern corner of Saganaga lake Lawson has found this granite in direct contact with the Ogishke conglomerate, where the granite cut the conglomerate and the Keewatin rocks in a truly irruptive manner.†† Recently the writer has been enabled to supplement the observations of Lawson by finding another contact between the conglomerate and the granite near the southwestern corner of the granite area. At this place the irruptive nature of the granite in the clastic rocks is clearly seen; it cuts across the strike of the conglomerate and has forced its way in between the different layers. The granite has also been found

*Geol. and Nat. Hist. Survey of Minn., 9th (1880) Ann. Rept., p. 82; 10th (1881) Ann. Rept., p. 88; 16th (1887) Ann. Rept., pp. 67, 69.

†Amer. Jour. Sci., iii, vol. xxxiv, p. 261, Oct., 1887; U. S. Geol. Survey, 7th Ann. Rept., p. 421.

‡Geol. and Nat. Hist. Survey of Minn., 16th (1887) Ann. Rept., pp. 233-269, 357; Amer. Jour. Sci., iii, vol. xxxiv, p. 314, Oct., 1887; Amer. Geologist, vol. i, pp. 14-24, Jan., 1888; Bull. Geol. Soc. Amer., vol. i, pp. 386-388.

§U. S. Geol. Survey, 10th Ann. Rept., pl. xlii.

||Amer. Geologist, vol. vii, p. 324, May, 1891.

**Bull. Geol. Soc. Amer., vol. i, pp. 387-393.

††Amer. Geologist, vol. vii, p. 324, May, 1891.

near by in irruptive contact with undoubted Keewatin rocks.* In consideration of the above facts—the relation of the Saganaga granite to the Ogishke conglomerate and to the Animike—there can no longer be any doubt as to the relative ages of the two series; the latter is much younger than the former, being separated from it by a great unconformity and a long erosion interval. The same is also true of the Animike and the Keewatin, no matter what is the age of the vertical schists on which the Animike lies at Gunflint lake.

Relation of the Ogishke conglomerate to the Keewatin. This is a subject which as yet cannot be regarded as definitely settled. Van Hise† considers the two as different formations separated by an unconformity. But thus far no entirely conclusive evidence on this point has been found. A. Winchell‡ thought that the two were one and were not separated by any interruption in deposition. And it must be admitted that in many cases the conglomerate is seen to pass into schists and slates which, as far as the author knows, have not yet been separated from the Keewatin proper either *lithologically* or by any *structural break.* There is still need of more detailed observations on this point, but it can safely be said that all are agreed that the conglomerate is more recent than most of the Keewatin,—no matter whether it is considered as a part of the Keewatin or as an infolded younger series. For the present it is perhaps better to consider the conglomerate as a part of the Keewatin.

No attempt to parallelize the Ogishke conglomerate with other formations in the lake Superior region is here necessary, it being the only object of this article to present briefly the various opinions on the position of the conglomerate and to state its actual relations, so far as is known, to the rocks in its immediate vicinity. The terms Keewatin and Vermilion have been used in the sense employed by the Minnesota survey,—*i. e.*, the former is the series of greenstones, graywackes, slates and earthy and semi-crystalline schists extending from Vermilion lake to and through

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*More detailed accounts of these contacts will appear in forthcoming reports of the Canadian and Minnesota surveys.

†Amer. Jour. Sci., iii, vol. XLI, pp. 117-137, Feb., 1891.

‡Geol. and Nat. Hist. Survey of Minn., 16th (1887) Ann. Rept., pp. 347, 348. Proceedings A. A. A. S., XXXVIII, 1889.

Knife lake; the latter is the series of holocrystalline mica and hornblende schists that often occur both north and south of the former.

The term "Ogishke conglomerate" has been used in this paper, as before stated, as referring to the conglomeritic terrane of nearly vertical dip, which lies on the shores of and to the north of Ogishke Muncie lake. This conglomerate has always been considered as a single formation, but in 1888 N. H. Winchell* stated some evidence for the existence of two conglomerates near this place and separated them into an upper and a lower member, which he provisionally referred to the Animike and Keewatin respectively. However, the younger of these is largely seen to the southeast of Ogishke Muncie lake and has not been studied by other geologists. So in this paper the older of these two conglomerates is the one under consideration.

Summary. The Animike and the Ogishke conglomerate can no longer be parallelized, as has often been done, for the former is separated from the latter by a great structural break and a long erosion interval. For the same reason the Animike can not be correlated with the Keewatin. The relation of the Ogishke conglomerate to the Keewatin has not yet been conclusively established, but all agree that it is younger than most of the Keewatin, and for the present it seems best to consider it as part of the Keewatin.

Petrographical Laboratory of the Johns Hopkins University, Baltimore, April, 1892.

NOTES ON THE STRATIGRAPHY OF A PORTION OF CENTRAL APPALACHIAN VIRGINIA.

By N. H. Darton, U. S. Geological Survey, Washington, D. C.

It is the purpose of these notes to describe the salient features of the stratigraphic column of the region, to assign definite names to certain of its members, and to call attention to a significant unconformity at or near the base of the Devonian. The field studies were made mainly in connection with the preparation of a detailed geologic map of Augusta, Highland, and portions of ad-

*Geol and Nat. Hist. Survey of Minn., 17th (1887) Ann. Rept., pp. 97-98.

jacent counties covered by the "Staunton Sheet" of the U. S. Geological Survey. This map will soon be published, together with sections and explanatory text, so that information regarding the distribution of the formations and their structure need not be given here.

The principal geologic publications relating to the region are the reports* and notes† of the State Survey by W. B. Rogers, and a paper by J. L. Campbell, "Silurian formations in Virginia."‡ Although Rogers' observations were made over half a century ago, his reports, and especially the notes, give a remarkably accurate and comprehensive account of the stratigraphy of Appalachian Virginia, but they are so brief that local features are not described. In the classification of the Paleozoics Rogers subdivided them into sixteen groups, to each of which a Roman numeral was assigned as a name. For the Carboniferous formations descriptive or geographic names were also proposed. These numerals have been used to some extent by subsequent writers, but names from the New York series have gradually been introduced, and in the section on the Virginias in Macfarlane's Geological Railway Guide, Rogers employs New York names together with his numerals, for the formations below the Lower Carboniferous.

Campbell's paper describes a section from Lexington to Warm Springs valley, and includes a table of the Silurian rocks "with their subdivisions compared with equivalent epochs of Dana's Manual."

Although the greater number of groups of the Lower Paleozoic of New York extend through Pennsylvania, and are more or less distinctly represented in Virginia, many of their component formations lose their distinctive characters, and their stratigraphic range is not apparent in the Virginia sections. Owing to this lack of evidence as to the precise stratigraphic equivalency and range of the Virginia formations in terms of the New York series, the use of New York terms is misleading. In the application of the New York nomenclature for Virginia formations names were

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*Reports of Progress of the Geological Survey of the State of Virginia, (1836-1841).

†The Virginias, Vol. 3, p. 194; Vol. 4, pp. 12, 13, 23, 38, 39, 59, 60, 71, 72, (1882-1883).

‡Am. Jour. Sci., 3d series, Vol. 18, pp. 16-29, 119-128.

selected somewhat arbitrarily and applied to beds in most cases comprising a much greater stratigraphic range than the name implies, including deposits having coördinate names in New York, but not presenting typical characters in Virginia. The system of classification and nomenclature by which I was guided in mapping the formations in central Appalachian Virginia is the one adopted by the U. S. Geological Survey and described in the Tenth Annual Report of the Director, pages 56 to 79. The following quotations from this report are given in explanation:

"The structural divisions shall be the units of cartography and shall be designated *formations*. Their discrimination shall be based upon the local sequence of rocks, lines of separation being drawn at points in the stratigraphic column where lithologic characters change. * * * In every case the definition should be that which best meets the practical requirements of the geologist in the field and the prospective user of the map; that is to say, each formation should possess such characteristics that it may be recognized on the ground alike by the geologist and by the layman.

"As each lithologic unit is the result of conditions of deposition that were local as well as temporary, it is to be assumed that each formation is limited in horizontal extent; the formation should be recognized and should be called by the same name as far as it can be traced and identified by means of its lithologic characters, aided by its stratigraphic associations and its contained fossils.

"The formations shall receive distinctive designations. The most desirable designations are binomial, the first member being geographic and the other lithologic. * * * When the formation consists of beds differing in lithologic character, so that no single lithologic term is applicable, the word "formation" shall be substituted for the lithologic term (e. g., Potomac Formation).

"In the application of formation names, the laws of priority and prescription shall be observed; but in general the name previously given to a structural unit of unlike definition shall not be given to the newly defined formation."

As the Staunton sheet is to be the first published of the maps of Appalachian Virginia, it was necessary in its preparation to carefully consider a nomenclature for the stratigraphic units for the region, and to select names which involved no further correlation than was at present practicable. To this end a few names already known were adopted, together with several new names derived from prominent localities in the general region. These names are applicable for all of central Appalachian Virginia, and in some cases for a wider area. They are given in the following list in which are classified the strata from Silurian to Lower Carboniferous:

Group.	Names adopted by U. S. Geol. Survey.	Rogers' number.	Other names which have been used.	Thickness.
Carboniferous.	Greenbrier limestone (W. B. Rogers.)	XI		
	Pocono sandstone (2d Geol. Surv. of Pa.)	X	Montgomery grits (W. B. Rogers.)	600 to 800 ft.
Devonian.	Hampshire formati'n	IX in part.	Catskill (in part?)	1000 to 1400 ft.
	Jennings formation	VIII "	Chemung " "	2800 to 3200 ft.
	Romney shales	VIII "	Hamilton " "	500 to 900 ft.
Silurian.	Monterey sandstone	VII	Oriskany	0 to 300 ft.
	Lewistown limestone (2d Geol. Surv. of Pa.)	VI	Lower Helderberg	300 to 600 ft.
	Massanutten sandst'n	IV and V	Medina and Clinton	600 to 800 ft.
	Martinsburg shales	III	Hudson River	800 to 1400 ft.
	Shenandoah limestone	II	Valley limestones. Trenton, Chazy, Levis, Calciferous.	1500 ft.

The term "Shenandoah limestone" is thought to be very appropriate, for the Shenandoah valley and river are well known features of its area. The formation comprises in the Staunton region a great mass of impure magnesian limestones below, grading upwards through a series of cherty beds of no great thickness into several hundred feet of light-colored, heavily bedded, purer limestones. The lower beds were not found to be fossiliferous. In the cherty beds only a few middle Ordovician gasteropods were found. In these beds the distribution of cherts is irregular in amount, horizon and continuity. The upper member is sparingly fossiliferous at many localities with a middle to upper Ordovician fauna in which the forms *Orthis occidentalis*, *O. testudinaria*, *Leptæna alternata*, and *Chætetes lycoperdon* were predominant. *Pleurotomaria subconica*, *Conularia trentonensis*, *Platynotus trentonensis* and several others were also noted.

In his reports and notes Rogers made no attempt to subdivide the great limestone series but fully recognized the charactertistics of its several members. In his contributions to Macfarlane's Guide the upper beds are placed in the "Trenton," and this designation has been generally applied to them. J. L. Campbell, in the paper above referred to, describes five subdivisions in the Lexington region, but in the Staunton region no lines of separation were found to be sufficient for areal distinction.

The Martinsburg shales succeed the Shenandoah limestone with a thin series of alternating thin bedded limestones and slates at their base. The name is taken from Martinsburg, in the Shenandoah valley in West Virginia, a region in which the formation is extensively and typically exposed. Its largest areas are in the great syncline of the Massanutten mountains, and the long narrow area bordering the great valley on the west along the flanks of Little North mountain. The rocks are slates and shales, mainly of dark color; in the Massanutten syncline thin beds of sandstone are included, and occasional limestone beds or calcareous streaks occur at other localities. The beds are fossiliferous at many points; graptolites are found in the basal beds, notably in some light colored weathered shales in cuts of the Chesapeake & Ohio railway, two miles east of Staunton and further east; along the Little North mountain, and in the Warm Spring, Crab Bottom and other anticlinal valleys westward, remains of upper Ordovician brachiopoda are moderately abundant. The forms most frequently met with are *Leptæna sericea*, *L. alternata*, *Orthis testudinaria*, *O. pectinella*, and *Modiolopsis modiolaria*. The precise equivalency of the formation is not known, but judging from its general relations and fauna it probably comprises the Utica, Hudson River, and possibly small amounts of adjacent formations of the New York series. It is the No. III of Rogers' reports and has generally been called "Hudson River."

The Massanutten sandstone receives its name from the prominent Massanutten mountains in which it is typically developed. It also constitutes the Little North mountain, and many other prominent ridges in Appalachian Virginia.

The rocks of the formation vary in local characters, mainly in color, thickness of bedding and degree of silicification, but white and red quartzites prevail. In most sections the basal beds are alternating beds of dark sandstones and shales; these are succeeded by white and grey quartzites, which in turn give place to thinner bedded red and brown sandstones and shales. The formation was separated into two portions, numbers IV and V, by Rogers, the lower part supposed to be equivalent to the Medina sandstone, and the upper shaly series to the Clinton, Niagara and Salina of the New York series; but while this subdivision may be practicable in some sections of the state, it would be most arbitrary and variable in the region to which these notes relate. The fossil ore horizon containing a Clinton fauna is not well developed in the region west of Staunton, and fossils are rare in any portion of the Massanutten sandstone series. In the Goshen pass there are several beds bearing molluscan remains, and Scolithus (verticalis?) and plants are conspicuous at some localities.

The Lewistown limestone is believed to be the southern extension of the beds comprised under that name in south central Pennsylvania. The formation is a light colored, heavily bedded, relatively pure limestone, of very uniform character. The occurrence of cherty beds in its upper portion is a characteristic feature, and it is also notably fossiliferous. The fauna is Lower Helderberg, but in its lower portion are also intermingled *Orthis elegantula* and *Spirifera niagaraensis*, representative Niagara forms. The more plentiful Lower Helderberg species are *Zaphrentis roemeri*, *Streptelasma stricta*, *Orthis oblata*, *O. perelegans*, *Streptorhynchus wolworthania*, *Strophomena rhomboidalis*, *Strophodonta headleyana*, *S. beckii*, *Cyrtia dalmani*, *Neucleospira ventricosa*, *Spirifera cyclopterus*, *S. concinnus*, *S. perlammellosus*, *S. macropleura*, *S. vanuxemi*, *Rhynchonella nobilis*, *R. formosa*, *R. abrupta*, *Eatonia medialis*, *Atyrpa reticularis*, *Pentamerus galeatus*, and many others. The beds have been called Lower Helderberg by most writers, but they unquestionably represent a somewhat greater stratigraphic range, and the name used by the Second Geological Survey of Pennsylvania has been adopted for them.

The formation is brought up very often in the anticlinals of central Appalachian Virginia, and it is a conspicuous and valuable member of the Paleozoic series. It thins gradually eastward, and southwestward it disappears for some distance in the New River region, to reappear in the southwestern corner of the state.

The Monterey sandstone is an arenaceous bed, everywhere closely associated with the Lewistown limestone from central Virginia through Pennsylvania. It is a coarse grained, light colored sandstone or moderately silicified quartzite, usually friable in its weathered outcrops. It is number VII of Rogers, and has generally been called Oriskany. Its abundant and varied fossils are mainly of Oriskany forms, but Lower Helderberg and Hamilton fossils are intermingled to a greater degree than in the New York Oriskany. The most distinctive Oriskany species recognized were *Orthis hipparionyx*, *O. musculosa*, *Spirifera arenosus*, *S. arectus*, *S. pyxidatus*, *Eatonia sinuata* and *Rensselaeria ovides*, but there are many others.

The beds undoubtedly comprise not only the Oriskany, but in their upper portion the representatives of the several coordinate members of the Corniferous group. For this reason and the general uncertainty of precise correlation a new name has been adopted for the formation. This name is that of the county seat of Highland county, Virginia, a region in which the formation is extensively developed. Whether to class the Monterey sandstone in the Devonian or Silurian is a question which will have to be decided by the paleontologists.

Between the Monterey sandstone and the slates of the next succeeding formation there is an unconformity by erosion which presents some interesting features. Its vertical extent is not great, and it is apparently confined to the more eastern series of exposures, but it appears to extend for some distance along the Appalachians. In the region west of Staunton the Monterey sandstone beds are eroded to a varying depth which reaches its maximum in an area northeast of Goshen, where the black slates of the Devonian lie on an irregular eroded surface of the cherty member of the Lewistown limestone, the Monterey sandstone having been entirely removed. The southern extension of the unconformity has not been studied with care, but the abrupt break between the black slates and Monterey sandstone is frequently observed for many miles southward. The absence of the Monterey sandstone and Lewistown limestone in the New River region is probably due to this unconformity, the occasional masses of black chert occurring in their place being the remains of the detritus of the latter. In Pennsylvania similar relations have been described in some of the central counties, where the "Oriskany" and more or less of the associated formations have been locally removed.

In central Virginia and also in Pennsylvania to a less extent there are iron ore deposits at the base of the Devonian shales. In Virginia these deposits have been extensively worked at Low Moor, Longdale, Victoria Mines, Ferrol, Pond Gap, and many other places, and their existence appears to be closely related to the unconformity. I have examined these deposits at several typical localities, and they appear to lie on the eroded surface, where they were probably deposited as bog ores in shallow basins of greater or less extent. They have since been buried under the great mass of Devonian and Carboniferous deposits, and more or less secondary arrangement has taken place. This secondary deposition would be necessary, perhaps, to account for the nature of the ores and the impregnation of the surrounding rocks with more or less ferruginous material.

The Devonian formations in central Appalachian Virginia comprise from 5,000 to 6,000 feet of arenaceous and argillaceous deposits, separable into three series. The basal members are fissile shales, in greater part black or dark brown in color, containing occasional thin beds of sandstone and limestone. Their average thickness is about 600 feet. They give place to a series of light colored shales, in which olive, grey, and buff tints prevail, with interbedded light colored sandstones, averaging in all about 3,000 feet in thickness. The local sequence of beds in this series is variable, but the medial portion consists largely of arenaceous members. The upper series is characterized by thin bedded, relatively hard, more or less micaceous sandstones with shale intercalations, in greater part dull red, dark grey, and brown in color. Its average thickness is about 1,200 feet.

These series intergrade through beds of passage often amounting to several hundred feet in thickness, but this amount is variable in different parts of the region. In his reports and notes Rogers classes the two lower series under his No. VIII, and separates the upper member, possibly more, as No. IX. The three series have also been more or less generally known as Hamilton, Chemung and Catskill, but without any definition of their range. Notwithstanding the extensive intergrading, the series are so well characterized as wholes that it seemed best to separate them as formations. As in the case with most of the other formations, it was found that there were no names in existence which could be employed with any degree of definiteness, so new names were selected. The names adopted were Romney shales, from Romney in West Virginia, for the basal series of dark shales, Jennings formation, from Jennings' gap and Jennings' branch in western Augusta county, Virginia, for the medial series of light colored shales and sandstones; and Hampshire formation from Hampshire county, West Virginia, for the uppermost series of dark sandstones. The Devonian formations are not fossiliferous at many horizons in the region west of Staunton. In the Romney shales the following species are Corniferous: *Discina lodensis*, *D. minuta*, *Orthis leucosia*, *Strophodonta demissa*, *Cyrtina hamiltonensis*, *Spirifera mucronatus*, *S. granulifera*, and *Leiorhynchus limitaris*. This is a Hamilton group fauna, but the stratigraphic range of Hamilton group equivalents in the Romney shales is not apparent, and Hamilton deposits probably extend some distance above.

In the Jennings formation very few beds are fossiliferous, and they are mainly in the medial beds where Chemung and Portage forms occur comprising *Spirifera disjuncta, S. mesocostalis, Streptorhynchus chemungensis, Chonetes scitula,* and others.

The Hampshire formation has yielded only a few plant remains which throw no light on the equivalency of the formation, but no doubt it comprises the representatives of the Catskill in their entirety or in greater part.

The Pocono sandstone is apparently the southern extension of the beds which bear the name in Pennsylvania. It is the No. X of Rogers. Its basal beds are coarse grained, quartzite sandstones, sometimes conglomeratic, massively bedded, usually light grey in color, and always constituting either a prominent ridge or protecting mountain cap. Higher members are thinner bedded and dark in color, and contain layers of slate with thin irregular coal beds. These coals have been worked at some localities but usually without profit, for the beds are thin, irregular and generally much crushed. Lower Carboniferous plant remains occur in the coal-bearing slates but no molluscan remains were observed.

On the Staunton sheet the Pocono sandstone caps Elliott's knob and various other high summits, particularly along the Shenandoah mountains, and it also constitutes the high, narrow ridge known as Narrow Back mountain.

The Greenbrier limestone has been described with considerable detail by Rogers, and I have nothing to add to his descriptions.

ON THE SIGNIFICANCE OF THE WHITE CLAYS OF THE OHIO REGION.*

By Frank Leverett.

The fact has long been known that in southeastern Indiana and southwestern Ohio the southern portion of the glaciated district is covered to a depth of several feet by clays, distinctly different in color and structure from the underlying glacial beds, and from the surface portions of the glacial drift further north. In the In-

*The work whose results appear in this paper was carried on under the supervision of Pres. T. C. Chamberlin, with whose permission this paper is published in advance of the more detailed official report.

diana Survey Reports the tracts covered by these clays are spoken of as "slash land," and in the Ohio Reports they are called the "white clay districts." It has also been known for some time that there are somewhat similar clay deposits in southern Ohio outside the glacial boundary. So far as I am aware these deposits outside the glacial boundary have never been correlated with the white clays that cover the southern portion of the glaciated district, nor has a common origin been ascribed to them. On the contrary, they have been attributed to quite distinct agencies and conditions in the one district from those which have been assigned in the other. The clays outside the glacial boundary have been quite generally attributed to a submergence caused by the hypothetical Cincinnati ice-dam, while those within the glacial boundary, being evidently incapable of explanation on this hypothesis, have been attributed to organic agencies such as plants, earthworms, ants, beetles, etc., which bring fine material to the surface.*

It is the aim of this paper to show that these deposits are synchronous, that they have a common origin, that that origin was independent both of ice-dams and of organic agencies, and, furthermore, that they furnish important evidence concerning the sequence of events in this region during the glacial period.

In the summer and autumn of 1889, I made an examination of the portion of the upper Ohio region in the vicinity of the supposed Cincinnati ice-dam, extending my observations up the river as far as the point where the glacial boundary bears away to the northeast. Careful comparison was made between the white clays, or silts, on Beech Flats and adjacent districts in Pike, Highland and Adams counties, Ohio, lying outside Wright's glacial boundary,

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*The greater part of the literature, relating to these clays, and also that relating to the Cincinnati ice-dam, is comprised in the following references:

E. Orton, Geology of Ohio, Vol I, 1873, pp. 444-446.

E. T. Cox (and associates), The County Reports of the Indiana Survey pertaining to the southeastern counties of Indiana.

G. F. Wright, Amer. Journ. Sci., July, 1883; Glacial Boundary in Ohio, 1884, pp. 73-76, 81-86; Ice Age in North America, 1889, pp. 326-350; Bull. No. 58, U. S. Geol. Survey, 1890, pp. 83-104.

I. C. White, Proc. A. A. A. S., 1883, pp. 212-213; Glacial Boundary in Ohio (Appendix) 1884, pp. 81-86; Amer. Jour. Sci., Vol. 34, 1887, pp. 374-381; Bull. Geol. Soc'y Amer., Vol. I, 1890, pp. 477-479.

J. P. Lesley, Penn. Second Geol. Survey (Z), 1884, pp. IX to XI.

E. W. Claypole, The Lake Age in Ohio, Trans. Edin. Geol. Soc'y, 1887.

T. C. Chamberlin, Bull. No. 58, U. S. Geol. Survey, 1890, pp. 17-38; Bull. Geol. Soc'y Amer., 1890, Vol. I, pp. 472-475, 478-479.

F. Leverett, Proc. Boston Soc. Nat. Hist., Vol. XXIV, 1890, pp. 455-459.

and attributed by him to a submergence occasioned by an ice-dam at Cincinnati, and those which cover the glacial drift further west. No essential difference of any kind could be detected. In both localities the clay has a depth of 2—5 feet, is nearly free from pebbles and coarse grains, and is usually so compact as to be almost impervious to water; sandy pockets occur in it, and there are places where the clay seems to graduate into a sand or fine gravel, it also frequently exhibits indistinct lamination. Such pebbles as occur are either cherty or are of distant (mainly Canadian) derivation, no limestones having been observed. The clay contains very little calcareous material. The absence of limestone pebbles and the small amount of calcareous material may, however, be due to removal by leaching subsequent to the deposition. Concretions of iron oxide are common and conspicuous features, occurring in the form of balls in all sizes from one-half inch or more in diameter down to barely discernible grains. The following result of a chemical analysis of the clay confirms the evidence derived from an examination of the coarse particles of the deposit. The analysis was made by T. G. Wormley, a chemist of the Ohio Survey, and the specimen is from western Highland county which lies within the glaciated district. It appears in the Geology of Ohio (Volume I, page 445):

Water combined	5.54
Silicic acid	62.60
Alumina	18.90
Sesquioxide of iron	6.30
Manganese	0.20
Phosphate of lime	0.63
Carbonate of lime	1.89
Carbonate of magnesia	1.82
Potash and soda	2.32
Total	100 10

Specimens of the clays covering Beech Flats, in Pike county, Ohio, and of those covering the till in Highland county, 15–20 miles back from Wright's glacial boundary, have been submitted to Prof. R. D. Salisbury for microscopic examination. He finds no essential difference in the specimens. In both situations they consist mainly of quartz grains, among which are feldspar fragments, hornblende and possibly epidote and augite; there are also minute iron oxide concretions and coarse grains of chert. The material is largely angular, even when the grains are of sufficient size to have been liable to rounding under favorable conditions.

Not only are the clays of these two localities similar in macroscopic and microscopic aspect, but they form a practically continuous sheet extending from the Beech Flats and adjoining lowlands outside Wright's glacial boundary westward onto the glaciated districts of southwestern Ohio, northern Kentucky and southeastern Indiana, occupying the site of the hypothetical Cincinnati ice-dam and showing as strong development below (west of) the site of the supposed dam as they do above it. The fact that these clays cover a part of the glaciated district proves that their deposition occurred subsequent to the time of maximum glaciation, and their distribution shows that the ice-sheet nowhere reached the Ohio river while they were being deposited. It is evident, therefore, that their deposition cannot be attributed to an ice-dam on the Ohio at Cincinnati or at any point below.

A feature of much importance in connection with these white clays is a black soil with leached and highly oxidized subsoil which immediately underlies them. The structure of this soil corresponds with that of the underlying drift sheet and as a rule it appears to be inseparable from it, though the weathering and the addition of humus has given it an aspect somewhat different from the unweathered portion of the drift. It is of very common occurrence and indicates the lapse of a considerable interval between the retreat of the ice-sheet and the deposition of the clays Its presence effectually disproves the current theory that the white clay was derived through organic agencies, from the underlying sheet of glacial drift.

It has been suggested that the presence of the white clays if not explicable on the foregoing hypotheses, might be explained on a theory of general submergence due to a depression of the region to sea-level, the main objection urged against this theory having been that it involves a great change in altitude. The facts now ascertained, however, remove this objection by indicating the occurrence of a depression of several hundred feet, but at the same time raise other and more serious objections to the theory of general submergence. It is scarcely probable that a body of water of the magnitude indicated, involving as it must have done considerable time in its incursion and withdrawal, would leave no shore lines sufficiently marked to have attracted notice, but so far as I am aware none have been reported. Furthermore president Chamberlin informs me that he has personally examined portions of the states in which, on this theory, such shore lines should occur, and not only found none, but discovered no evidence of any kind to indicate the presence of such a body of water. It seems necessary therefore to look further for a solution of the problem.

Comparison has shown a marked similarity between the white clay deposit of the Ohio, and the great silt deposit of the upper Mississippi. All the phenomena of structure and distribution indicate that they originated under similar conditions. This being the case it is evident that a hypothesis which would account for the phenomena of the Mississippi region, would also account for those of the Ohio, so for a solution of the problem we need only apply, to the latter region, an explanation which has proved satisfactory in the former. A detailed study of the upper Mississippi region, particularly of that part of it which borders the driftless area, was made several years ago by Chamberlin and Salisbury, and led them to the conclusion that the distribution of the loess and associated silts and clays is best explained on a hypothesis of fluvio-lacustrine deposition.* Evidence was found that the altitude of the region was much below the present perhaps not far above sea-level, but instead of its being occupied by an inland sea, it is their conception that the valleys became silted up so that at the maximum of depression they were occupied by shallow, perhaps marshy, lake-like rivers many miles in width, whose waters moved slowly seaward from the edge of the melting ice-sheet. The constitution of these silts shows a direct derivation from glacial waters. The presence of shells of land mollusca in the silts, indicates that the region was subject to occasional or periodic overflow rather than to perpetual and deep submergence.

The applicability of this hypothesis to the Ohio region may be made more clear by a consideration of its application to a part of Illinois, where similar phenomena occur, but under more simple conditions. For nearly a hundred miles north from the extreme limit of glaciation in that state, and extending from the Mississippi river eastward to the hilly districts of southern Indiana, there is a generally flat surface on which there are few, if any,

*"The Driftless Area of the Upper Mississippi Valley." By T. C. Chamberlin and R. D. Salisbury. Sixth Ann. Rept. U. S. Geol. Survey pp. 211-216, 278-307.

morainic features, though there is a nearly continuous sheet of till. A large portion of this till sheet is covered by a white clay which we have correlated with the white clay of the Ohio region. It is similar to that deposit in structure and thickness, and overlies an old land surface with soil and leached subsoil. It may prove to be connected with the Ohio clays by a practically continuous sheet, the deposit having been traced across Indiana except in the driftless portion of the state which has not yet been examined.

The north boundary of this deposit is determined by a moraine of which it is apparently a dependency.* Northward from this moraine are several later ones, which were also formed under conditions of low altitude and slack drainage, as is shown by silt aprons which fringe their outer border. These moraines appear to have been formed in relatively rapid succession, no soil having been found separating the silts in their aprons from the underlying till. They are succeeded on the north by a series of moraines which were formed under conditions of high altitude and rapid drainage as is shown by gravel aprons and gravel terraces leading southward from them.

Returning to the Ohio district we find that the present north boundary of the white clays of southeastern Indiana and southwestern Ohio, is determined by a moraine, but evidently it is not the moraine with which the deposition was connected. That it belongs to a later period is shown by moraine headed terraces in neighboring valleys which contain gravel and sand, indicating clearly that they were formed under conditions of high altitude. How far the advance, marked by this moraine, extended beyond the one which produced the silts is not known. Two instances have been found where silts similar to the white clay occur beneath the till of the later invasion at points a few miles north of the moraine referred to. At Greensburg, Indiana, which lies perhaps five miles from the border of the white clay district, Pres. Chamberlin found good exposures of fossil-bearing silt or loess beneath the till of the later ice-invasion (See Third Annual Report of the U. S. Geol. Survey, p. 333). At Wilmington, Ohio, which is also situated a few miles north from the north border

*A line connecting the following cities will show approximately the distribution of this moraine: Litchfield, Hillsboro, Pana, Shelbyville, Mattoon, Charleston, Paris and Terra Haute.

of the white clay district, the late Dr. L. B. Welch found in many wells, at a depth of about 30 feet and beneath the till of the newer drift, a loess-like loam containing fossils. As yet it is not certain that these overridden silts should be correlated with the white clays, but they are of much significance in showing that the ice in the later invasion encroached upon silt covered districts.

The fact that the clay deposits become thinner toward the south and are gathered into the valleys, strengthens the view that the condition which obtained at the time of their deposition was one of overflow rather than of general submergence. In both Indiana and Ohio, the thickness at the border of the moraine is four or five feet, occasionally greater, and a gradual decrease is found in passing southward, the thickness on the interfluvial tracts in southern Ohio, 20-30 miles from the moraine, being little more than half as great. In Indiana I have made no examinations so far south of the moraine but am informed by Pres. Chamberlin, who has explored the drift covered region to some extent in the vicinity of the Ohio river, that there is scarcely any white clay on the interfluvial tracts for many miles north of the river. There is, however, loess-like silt, in small amount, along the Ohio below Louisville which he thinks may be correlated with these white clays. It is not improbable that the East White river carried a large amount of water from southeastern Indiana at the time the white clays were being deposited. The white clays have been traced down its valley to the point where it enters the driftless portion of southern Indiana, and they have there as strong a development as anywhere in that part of the state.

From facts presented in the above discussion it appears that the white clays and the moraines with which they are associated have a distinct chronological position, being separated from the earliest glaciation by an interval during which the till sheet was undergoing oxidation and leaching, and from the last glaciation by an interval during which a marked change in altitude occurred. Equally strong evidence of the occurrence of these intervals is found in the character of the drainage and the degree of erosion As to the relative length of the intervals, we can at present offer no opinion, little being known as to the length of time involved in the changes by which they are denoted.

THE RELATION OF SECULAR DECAY OF ROCKS TO THE FORMATION OF SEDIMENTS.*

RALPH S. TARR, Ithaca, N. Y.

CONTENTS.

I. Secular Disintegration.

(*a*) *Conditions of Decay.*

Rocks are composed of minerals in greater or less variety both as to character and quantity, and the decay of rocks depends upon both the chemical and mechanical weakness of the material. The chief factors in rock disintegration are the mechanical effects of heat, frost and organic life, and the chemical decay of minerals.

Quartzose rocks decay with extreme slowness and their disintegration is chiefly mechanical. Limestone disappears rapidly, but soil accumulates slowly because of the solubility of the component minerals, the insoluble impurities alone remaining. Slates and other clay rocks, being themselves largely composed of residual products, and hence not subject to extreme chemical alteration, produce soil slowly except by mechanical means. The rocks best fitted for rapid and extensive production of residual soils are the crystalline rocks both of igneous and metamorphic origin. This is particularly the case with those rich in the lime soda feldspar, hornblende and the like. These are broken up by decay into the less soluble silicates and the soluble protoxide bases. Since a given quantity of a very easily destroyed rock, such as limestone, disappears quickly, but leaves a small residuum, whereas the same quantity of a less soluble rock disappears more slowly but with greater residual product, the resulting amounts of residuum in the two cases, in a given time may not be widely different.

The chemical decay of rocks goes on often to a very great

*This essay was prepared for another purpose, and is in the main an abstract of the present knowledge on the subject. The scattered state of the literature on Secular Disintegration, and the general interest of the subject, has prompted me to publish this summary where it will be accessible.

depth, and in many regions a deep residual soil has been the result. The best conditions for the formation of such a soil are a moist climate and a region of abundant vegetation which supplies to the percolating water the necessary acids with which the chemical alteration of minerals is advanced. It seems also that secular decay proceeds more rapidly in warm than cold climates, though of this we have as yet no fair test, since the regions in the north so far studied have been recently glaciated and their residual soils removed. Theoretically this should be a factor of importance, for the abundance of decaying vegetation, the amount of rainfall, the duration of time when, through absence of frost, the water can percolate into the soil from the surface, and the greater temperature of the water in warm countries, are all in favor of the greater activity of rock decay in such regions.

(*b*) *Characteristics of Residual Soils.*

The ultimate result of secular decay is essentially a soil of uniform character, whatever the nature of the rock may be. This is so because as the process continues chemical alteration proceeds to the last degree, the greater part of the soluble salts are removed, and only the insoluble parts remain, and these are quite uniform in character. Thus Chamberlain and Salisbury* state that in the driftless area of Wisconsin the residual soil on the sandstone differs but little from that on the limestone except that it is compact on the surface and more siliceous below.

The *immediate* product of decay, however, depends largely upon the character of the source. According to professor Pumpelly† granites, syenites, gneisses, diorites, etc., produce argillaceous sand or sandy clay; porphyries, basalts, trachytic rocks, etc., produce ferruginous clays; impure limestones and dolomites undergo the greatest shrinkage leaving masses of sandy clay, often with chert; and calcareous sandstones and clays also leave sands and clays.

A residuum from secular rock-disintegration consists, in its best development, of several zones, grading insensibly downward into the undecomposed rock. On the surface it is a clay, more or less siliceous, composed almost entirely of insoluble minerals in a very fine state of division. This zone extends as

*Sixth Annual Rept. U. S. Geol. Survey, pp. 240-58.

†Am. J. Sci. 1879, XVII, pp. 133-144.

far down as *thorough* decay has extended. Below this the clay contains a greater percentage of soluble salts, is less finely divided and often contains undecayed masses of rock. Chert and pieces of quartz of moderate size are found in regions capable of supplying such substances, while in some of the soils derived from such igneous rocks as granite and basalt weathered and rounded boulders of disintegration, often fresh in the core, are common. This gradually passes into the quite thoroughly disintegrated but not completely decayed rock, where all the minerals are present in original form, if not in substance, and where the original structure may be plainly traced, although the rock is as easily torn to pieces as so much unconsolidated clay. When this occurs in rocks of metamorphic origin, the planes of schistosity are often as well defined as in the original unaltered rock. This by degrees grades into the perfectly fresh unaltered rock.

(c) *Distribution of Residual Soils.*

Such soils as the above are found in various parts of the world. In northern Europe and northern America they are absent, having been swept from the surface by the continental ice sheets. In America, in the Hoosac mountains, in western Massachusetts, the rock was found, in the western end of the Hoosac tunnel, to be deeply disintegrated, though no residual soil was found.*

At several points in southern Massachusetts, decay in the plutonic rocks is quite marked; and at Middlesex Fells, west of Cambridge, a diabase dike is deeply disintegrated, in places to a depth of twenty feet, to a gravel which can be easily worked with a shovel.† Rounded boulders with an undecomposed core are present in this mass. Similar cases occur in the very much rifted granite of Essex and Cape Ann, Mass.,‡ and these cases are post glacial, the disintegration being the same in glacially transported boulders as in the bed rock. In the Middlesex Fells dike the *roches moutonées* surface of the decayed diabase still retain the glacial striæ. These facts show how rapidly disintegration may proceed, even in a cold climate, in rocks of weak chemical composition. The process is not complete in these in-

*Hunt, Am. J. Sci., 1883, xxvi, 190-213.

†First noticed by Mr. J. B. Woodworth, of Harvard University.

‡Shaler, Ninth Ann. Rept., U. S. Geol. Survey, p 567; Tarr, Am. J. Sci., April, 1891.

stances, for so far it has gone no farther than mere disintegration. The production of a residual soil is a much slower process.

The case of the Hoosac mountains mentioned above, may be one in which a preglacially decayed rock has remained unremoved through the entire period of ice erosion. Whether this be so or not we have in the driftless area of Wisconsin, a very remarkable instance of a pre or interglacial residual soil in a region which was surrounded by ice, though itself untouched by the ice.* In this area there is a widespread clay, quite unlike drift clays in that it is never stratified, and contains no angular fragments. It is an exceedingly tenacious clay, retaining moisture, and when it dries forming a "joint clay." The grains of silica are somewhat dissolved and etched by solution and weathering, the alkaline bases are entirely decomposed and the more soluble residues removed, while only soluble substances remain. From the decayed limestone and dolomite strata, the lime and magnesia, together with such alkalies as may have been present, are dissolved away, the mechanically included foreign materials alone remaining. The average depth of this residuary material over the driftless area is 7.08 feet.

A more marked case of secular decay is found in the Atlantic coast states south of the glacial belt.† The mica schists of Pennsylvania and Maryland are often disintegrated to a depth of from fifteen to thirty feet, but the rock is merely disintegrated, not decayed, hence residual clay is not common. In Virginia and the Carolinas the rocks are often decayed to a depth of one hundred feet. Of this region, Dr. Hunt says‡ that the rocks "are often covered to a depth of a hundred feet or more, by the undisturbed products of their own decomposition, the protoxide bases having been removed by solution from the feldspars, the hornblende and the whole rock, with the exception of the quartzose layers, reduced to a clayey mass, still, however, showing inclined planes of stratification."

Other writers have described the same region. Russell§ mentions a dolerite dike in the Triassic sandstone of North Carolina,

*Chamberlain and Salisbury. The Driftless Area. Sixth Ann. Rept. U. S. Geol. Survey, pp. 240-258.

†Russell. Subaerial Decay of Rocks, etc. Bull. No. 52, U. S. Geol. Survey, 1889.

‡Chemical and Geological Essays, 1871-73, pp. 187, 250.

§Bull. 52, U. S. Geol. Survey, p. 12.

which, though originally so hard that it will ring under the hammer has been transformed to a yellowish clay that can be moulded like putty. Fresh sections to a depth of forty feet show this decay to the bottom, but the enclosing walls of sandstone show no alteration. The resulting product is essentially a kaolin with about seventeen per cent. of ferric oxide.*

Among the other instances of secular rock decay in the United States might be mentioned that of the Ozark mountains of Missouri, described by Prof. Pumpelly.† Here the secular dissolving away of the limestones, which carry from two to nine per cent. of silica and clay, has left residuary products varying in thickness from twenty to one hundred and twenty feet.

The best development of secularly decayed soil is in the tropics. In Nicaragua such decay has often reached to a depth of two hundred feet, according to Thomas Belt, who says that this kind of decay is common in the tropics and is chiefly confined to regions of forest.‡

The remarkable decay of the rocks in Brazil, which, with the associated phenomena, led Louis Agassiz to ascribe its accumulation to glacial action has been described by various writers. Darwin states§ that in the vicinity of Rio Janiero both the granitic (metamorphic?) rocks and talcose slates are decayed to a great depth. Every mineral except the quartz is softened sometimes to a depth of one hundred feet, but the foliation of the rock remains. Appalled by the vastness of the phenomenon, seemingly unlike anything at present in operation, he ascribed its formation to action beneath the sea. Of the same region Hartt says‖ that the gneiss hills are covered with a coat of red soil, structureless and unarranged, varying in depth from a few feet to one hundred feet. Sometimes there are included in the clay angular fragments of quartz and rounded masses of diorite, generally quite decomposed except at the very core. The gneiss beneath is decomposed to a depth of from a few feet to one hundred feet, the feldspars having been altered to kaolin, the mica having parted with its iron, but the planes of stratification still remaining.

*Insoluble alumina Al_2O_3 and Fe_2O_3 increase, but SiO_2, CaO, Na_2O, FeO, etc., decrease by this decay.

†Am. J. Sci , 1879, XVII, 133-44.

‡Naturalist in Nicaragua, 1888, p. 86.

§Geological observations, p. 427.

‖Geology and Physical Geography of Brazil, 1870, pp. 23-26.

In India there is a remarkable deposit of clay, called laterite, the origin of which the Indian geologists have not yet definitely determined.* It is a red, sometimes mottled, porous, argillaceous rock much impregnated with iron peroxide and sometimes resembling jasper, but not so hard as a purely siliceous mineral. It is often traversed by tubes, sometimes vertical, sometimes horizontal, and sometimes irregular, which are filled with clay. The rock when first quarried is so soft that it can be cut out with a pick; but it hardens greatly on exposure. There are two kinds of laterite, the "high level" and "low level," which in places seem to grade into one another, but which in their extremes are quite distinct, for the former is rarely stratified, while the latter is most commonly banded and bears evidence of marine origin. The low level laterite will be considered under the discussion of sediments derived from secular decay.

The upper laterite often passes insensibly into the underlying rock, whether it is igneous, metamorphic or sedimentary, the transition form being called lithomarge. Sometimes, however, the dividing line between lithomarge and bed rock is quite marked. The laterite is quite indestructible and the region occupied by it is generally barren. Its thickness varies from fifty to two hundred feet. The high level laterite occurs as high as 4,700 feet above sea level and is found chiefly on the traps of the Deccan plateau, though it also occurs on the older rocks several hundred miles from any traps. It must formerly have been much more extensive and perhaps formed a continuous sheet, though now very much dissected by erosion.

As to its origin, no definite conclusion is arrived at by the authors, though the low level laterite is believed to have been derived from the upper laterite partly by the action of the wind, partly by stream action. One suggestion in regard to the origin of the high level laterite is that it has been derived from the decay of a basalt sheet formerly more extensive. Numerous obections are found to this theory, chiefly the difficulty of accounting for such a sheet in many places where laterite is found. Another suggestion is that it represents the decayed product of a vast sheet of volcanic ash deposited during the formation of the Deccan traps. This theory the authors seem to think the most probable one thus

*Medlicott and Blanford, A Manual of the Geology of India, 1879, Vol. I, p. 348.

far offered, though it is confessedly offered merely in the effort to suggest something plausible and is quite without facts in its support.

Strangely enough, origin by secular disintegration is not discussed, though it may have been considered and found inapplicable for reasons not set forth in the treatise. To offer an explanation of a phenomenon simply upon the basis of the description of the phenomenon by others is extremely hazardous, and it is with much hesitation that I make the suggestion that the laterite may be the product of secular disintegration. So far as the description goes, it may well be of this nature. It is an indestructible clay of nearly uniform character sometimes grading downward insensibly into the rock below. As has been stated, residual soils differ but little according to the nature of the source from which they have been derived, and the uniform character of the laterite may thus be accounted for as well as its occurrence on both basalt and gneiss. The description tallies remarkably well with that of the residual soils of the southern states and Brazil. By removal into basins and valleys through subsequent denudation a stratified product might well result, and, when carried to sea and deposited, a rock like the low level laterite might be expected. This would account for the apparent gradation of the "low level" laterite into the "high level" form.

Enough has been said of the occurrence of residual soils to show that they are extremely widespread. They occur wherever conditions have been favorable. Given a moist climate in a region of slight topographic diversity and the conditions for the accumulation of a residual soil are brought about; and, if time is allowed such a soil will accumulate. In a mountainous region of diverse topography, little soil can accumulate, for it is washed off as rapidly as formed. In such regions the decay of rocks and the consequent production of sediments is probably more rapid than in a region whose rocks are protected from frost and other sub-aerial agents by a blanket of residual soil. Also, in arid regions, residual soils do not readily form, partly because of the general absence of humidity and vegetation, and partly because the soils which do form are quickly removed, either by wind or water, on account of the absence of protective vegetation and the general aridity.

II. *Formation of Sediments.*

(*a*) *General Statement.*

Products of rock disintegration and decay may aid in rock formation in either of six ways: 1st, they may remain in place and, unmoved, be buried beneath sediments,—such may be the fate of any of the residual soils at present exsting; 2d, they may be transported a short distance by "surface wash" or "creep," as in arid regions; or, 3d, they may be removed by wind; or, 4th, by ice; or, 5th, by rivers; or, 6th, by the sea. These will be taken up for consideration in their order. The first needs no especial mention, other than that already given it. One case where the products of disintegration have been buried in place, chiefly under their own overlying, decayed material, removed but a short distance, will be described in the latter part of the essay, under the discussion of sediments derived by the action of the sea direct.

(*b*) *By Surface Wash.*

Peculiar conditions exist in arid regions. Thorough rock decay is rarely if ever found in such places, for the reason that the essential elements of water and vegetable acids are not present in any considerable quantities. A certain amount of disintegration takes place, but there is little vegetation to hold the soil in place, and its almost constant dryness makes it an easy prey to the wind, by which the finer particles are blown hither and thither.

The peculiarity of rainfall brings about another condition—the phenomenon of surface wash or creep. The rare rains which fall, generally come in copious downfalls, and, as they fall on a surface which is parched and dry, they are often very quickly absorbed by the soil. Such desert regions are, as a rule, not occupied by well established drainage ways. The rains which are sufficiently copious to run off are rare, and the channels which they carve are often partially obliterated before another such rain occurs. There are broad tracts on which the rain finds no well established water-ways by which to escape. As it soaks into the parched, barren, and generally sandy soil, it tends to flow down the grade, and, in so doing, to carry some of the soil along with it; but often before the force of the accumulating waters is sufficient to carve distinct channels, the rains have ceased. Floods from violent cloudbursts in such places frequently become a moving mass of mud at their lower course.

The general effect of such conditions in arid regions of moderate slope is to produce great deposits of loose gravels extending far out from the mountain bases. These are not properly talus deposits, nor are they of the cone delta type, but are intermediate between the two and with some of the characters of each. They are found in the arid regions of the west about the base of mountains, buttes and mesas and often merge into cone delta deposits. I have seen walls of recent construction partly buried beneath this wash in the mesa region of eastern New Mexico.

Blanford* describes remarkable deposits of this character in Persia. Great gravel slopes in that country extend from the base of the mountains far out into the desert, often five or ten miles from their source. The foot hills are often quite buried beneath these gravels which bear some resemblance to lake deposits, but do not appear to be of this character. The angle of slope is from one degree to three degrees, there being sometimes a difference in elevation of from one to two thousand feet between the lower and upper ends. Much of the region is thus covered, and the thickness of the deposit is often several hundred feet. Near the source it is a coarse conglomerate, changing progressively down the slope to a gravel, and then to a sand, the latter covering the great desert flats and probably being in large measure transported thither by the wind. Blanford explains the gravel slope as a surface wash, the result of the conditions of aridity, and rare, concentrated rains, in the manner described above.

Similar deposits occur in India, and it is not impossible that the great gravel slopes of Patagonia ascribed by Darwin† to marine action may be in part of the same origin. The same conditions are imitated in a small way, in moist regions, on ploughed fields on hill sides. Instances of the downcreeping of the soil in these places are very common, and often the total result of a few years of such creeping is quite appreciable.

By a change in climatic conditions, and the development of river systems in these desert regions, much prepared load ready for transportation, will be found in these deposits; and the encroachment of the sea upon the gravel slopes would admit of a rapid deposition of extensive deposits by the working over of

*Superficial Deposits in the Valleys and Deserts of Central Persia, Quart. J. Geol. Soc., 1873, xxix, 493-503.

†Darwin, Geological Observations.

these. Some of the delta-like deposits of Tertiary age in the Himalaya mountains may be of this origin.

Very similar to and grading into these deposits are the cone deltas or alluvial fans of arid regions. They result from the inability of the streams to carry their load any farther. This is sometimes brought about by the absorption of the water by the soil, or by evaporation, when forms resembling gravel slopes are produced; but most commonly the decrease in carrying capacity is the direct result of the decrease in river slope. For this reason such deposits exist most commonly at the foot of mountains, opposite the ravines, forming a cone shaped delta. These alluvial fans often unite with one another by means of talus deposits, or by the surface wash, or even by actually meeting in their growth.* In the discussion of a paper on secular disintegration† by professor Pumpelly, Mr. Gilbert calls attention to these deposits in the arid regions of the west, particularly of the Great Basin, which are derived by processes chiefly mechanical and involving little rock decay. They accumulate in the valleys and at the foot of mountains, in alluvial cones needing only cementation to become an extensive conglomerate.

(c) *By Wind.*

Any one familiar with the conditions in the arid regions knows of the great importance of the wind as a transporting agent. Scarcely a day passes during which more or less sand and dust is not blown about; and very frequently great dust storms occur, during which much sand is transported, often to a great distance. Prof. Pumpelly states‡ that in a simoon the driving dust and sand hides the country under a mantle of impenetrable darkness and penetrates every fabric. It often destroys life by suffocation, and in places leaves a deposit several feet deep. Such wind blown material may find its way to the sea direct, or into streams and thence to the sea; but more commonly it remains on the land. The importance of this means of transportation is not fully known, for the subject has never been carefully investigated; but when it is so studied, it will undoubtedly be found to be a very important source of material for the formation of rocks.

*For a complete discussion of these deposits I refer to the following sources: Drew, Quart. J. Geol. Soc., 1873, XXIX, 441-471. Gilbert, Monograph I, U. S. Geol. Survey, 1890.

†Bull. Geol. Soc. Am. 1891, II, 224.

‡Secular Rock Disintegration. Am. J. Sci., 1879, XVII, 133-144.

An important contribution to this subject has been made by Baron Richtofen,* who tries to explain loess in China by this process. The loess in that country and in other parts of the world has long been a puzzle to geologists, and various attempts have been made to account for its origin, though as yet no thoroughly satisfactory general theory has been advanced. It is probable that loess is derived in a variety of ways, and the solution of the problem of its origin has perhaps been delayed by the attempt to find a universally applicable hypothesis.

In northern China the loess covers several hundred thousand square miles, often attaining a depth of two thousand feet. It is a calcareous loam, easily crushed to an almost impalpable powder, wholly unstratified and containing only land fossils. These facts seem to prove quite conclusively that it is not of marine origin, and the fact that it is found in the loftiest passes, as high as 8,000 feet above sea level, seems to prove that it is not lacustrine. It is found to contain innumerable vertical tubes which, it has been suggested, may be the casts of grass stems; so abundant are these that the rock cleaves vertically, and when, by the erosion of streams, through sapping or undermining, great blocks fall off, vertical cliffs remain.

Richtofen believes that these vast deposits are wind blown in origin. A "central area" is one in which evaporation exceeds precipitation. The in-blowing winds, aided by surface wash, transport the finely divided materials into such a region. The steppe vegetation characteristic of such a region would help to catch and hold the fine dust, and this grass, buried beneath the æolian deposits might leave by their casts such tubes as are found in the loess. Briefly this is Richtofen's theory for the origin of loess in China. Professor Pumpelly accepts this theory and extends it to explain the loess of Missouri.† In order to account for the great amount of material, which seems in excess of rock disintegration, he supposes that rivers charged with products of glacial attrition carried to the region material for the winds to transport.

Professor Pumpelly calls attention to the fact that, while there is much secularly disintegrated material in southern Asia, the feldspathic rocks of northern China and central Asia are as free

*China, 1877, I, 56-189.

†Secular Rock Disintegration, Am. J. Sci., 1879, XVII, 133-144.

from it as are the rocks of New England, which have been swept clear of all such material by the recent ice advances. Moreover the bare granite rock contains depressions seemingly due to erosion, without outlet, and varying in size from a few yards to several thousand feet,* and apparently the result of differences in rock texture. Such depressions would be expected to exist at the base of an area of secularly decayed material. From these facts the author argues that we may have here a source for the assumed æolian deposits of the loess. If it is assumed that China was exposed to the conditions which southern Asia has undergone, the country must at one time have been covered by a well marked residual soil. None now remains and it must have been swept away by some agent. Not by the sea, for there is no evidence of a marine incursion, nor by ice action, for evidences of the existence of glaciers are entirely wanting. The agency of the wind alone appears to remain to account for this change. A change in climatic conditions from moist to dry would set to work this powerful agent of transportation.

By such a transformation a series of deposits are rendered possible. The finest material driven great distances by the wind would finally settle and remain and accumulate under the protection of the steppe grasses in the region intermediate between the arid interior and the moist coast climates, forming a deposit not unlike loess; the coarser sands would form the drifting desert sands; and the still coarser parts would remain behind and form the characteristic coarse stony steppes. The conditions in China seem to suggest the plausibility of this explanation.

Pumpelly offers a similar explanation for the loess of the trans-Mississippi regions. During early times the region of the Rocky mountains must have been the seat of secular disintegration, though now none of its products remain in place. The present aridity and prevailing west winds may account for its removal and for the presence of loess as far east as Kansas. The loess deposits of the Rhine and of the Central states may have been accumulated by æolian action, but in these cases the supply may more likely have been glacial flour which itself may have been derived by the glacier from secularly decayed soils.

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*Pumpelly, Geological Researches in China, etc., Smith'n Contr. Knowledge, xv, Art. 4, 26, 72, 73.

Chamberlain and Salisbury, speaking of the loess of Wisconsin* describe it as neither a sand nor a clay, but intermediate between the two, being generally coarser than residuary earths. The particles are, however, angular and irregular as in the case of residuary earths. Its depth in that region is from ten to fifteen feet over a wide area.

These considerations are in the main theoretical, but the theory has much to commend it, since it accounts, apparently in a satisfactory manner, for a most puzzling series of deposits.

(*d*) *By Ice.*

The movement of a sheet of ice over a region which had been subjected to secular disintegration would result in the removal of the loose, decayed rock, which would furnish to the ice great quantities of sediment. During the melting of the ice, and at all times at its front the streams would be furnished with great burdens of sediment, which, either deposited in the valleys or carried to the sea, would aid greatly in rock formation. The final disappearance of the ice would leave the surface of the country littered with unstratified drift.

Something of the same condition would result from the passage of an ice sheet over an undecayed rock, but the materials supplied would be less in amount. Ice cannot cut without tools. Leaving out of consideration valley glaciers,† there are but two ways with which ice can be supplied with cutting tools, one by the loose material which it can pick up, the other by actually rending rocks asunder. The former supply ceases when the zone of disintegration is passed and the latter soon follows. The erosive action of ice is to round, smooth and polish the surface over which it passes and thus to lessen the possibility of obtaining a supply of cutting tools. As the period of ice occupancy of a land continues, its power of erosion must diminish and finally become almost nothing. It will slide over rounded surfaces practically without any destructive effect and the streams will issue from its front with a very slight load of sediment.

The great mass of detritus left by the ice of the glacial period

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*Driftless area of Wisconsin. Sixth Annual Rept. U. S. Geol. Survey, 278-307.

†In valley glaciers and in continental glaciers where mountain peaks project above the ice, detritus is furnished as a talus from the cliffs.

has been a source of perplexity to many geologists and early led to a greatly exaggerated notion as to the amount of rock actually removed. Subsequent studies have shown that the pre-glacial topography remains with remarkable distinctness where not buried beneath glacial accumulations, and, consequently, that but little bed rock has been removed. Moreover, the case of the Hoosac mountains, described above, shows that in this place at least the original pre-glacially decomposed rock has not been all removed. If now it be assumed that in pre-glacial (or inter-glacial) times a considerable accumulation of secularly decayed rock existed upon the surface, the present accumulations may be accounted for without supposing a great deal of planing down of the rocks themselves. By this view the ice has acted more as a transporter of detritus already prepared than as a producer of such detritus.

Moreover, this view of the glacial conditions also furnishes an explanation (in part at least) of that much discussed question of the origin of rock basins in glaciated regions. It yet remains to be proved that ice can, on a large scale, gouge out depressions. That under peculiar circumstances this is done is unquestioned, but that all or even a large per cent. of rock basins are the result of this action is not yet satisfactorily demonstrated. In a region of secular disintegration the rock surface would necessarily be irregular and one containing numerous basins where rock of an easily disintegrated nature exists.

Pumpelly* suggests this point and accounts for similar basins in China by the action of wind in removing secularly decayed materials. Chalmers,† speaking of the rock basins of New Brunswick, says: "These lake basins have evidently been formed by the sub-ærial decay of the rocks *in situ* in Pre-Quaternary times, the softer limestones, graphitic schists and ferruginous rocks having been more deeply acted upon than the gneisses and felsites." How far this idea can be extended by actual demonstration is not at all certain for it has not been given the careful attention which it deserves. Secular decay undoubtedly produces just such forms, for it has regard chiefly for the chemical durability of the rock.

In their description of the driftless area‡ Chamberlain and Sal-

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*Am. J. Sci., 1879, XVII, 133-144.

†Rept. Prog. Canada Geol. Survey, 1885, I, 17 GG.

‡Sixth Ann. Rept. U. S. Geol. Survey, 249.

isbury make the point that the glacial deposits of Wisconsin are not derived from a secularly decayed soil. They state that residuary products are almost completely robbed of alkalies, containing chiefly quartz, undecomposable silicates and ferric oxide. Drift clays, on the other hand, are calcareous, and in some of these clays there is forty per cent. of magnesian limestone. "The drift clays are, in short, rock flour, and not, as are the residuary earths, the products of rock rot."

I think that this argument is not valid, for the reason that but a small part of secularly decayed rock consists of residual soil. Beneath the surface it becomes more and more like the rock from which it has been derived and finally passes insensibly into it. This last must have been the material with which the ice was working in its last stages. Moreover, in places, perhaps over the greater part, the ice was then at work on the undecayed rock, and the churning up of this with the products of disintegration and secular decay might readily introduce a large element of calcareous matter.

(c) By Rivers.

Residual soils can accumulate only where decay is in excess of denudation. Regions of considerable topographic diversity are generally free from accumulated soils and these soils are most liable to form where the streams are not rapidly eroding. As an instance of this reference may be made to Mr. Russell's paper* in which it is stated that where erosion is rapid, in the southern Piedmont region, owing to the more rapid solution of certain limestones, and the consequent standing out of other rocks, no residual soil remains. The presence of vegetation aids greatly in the retention of such soils. and this protective effect often allows the streams to run clear even when their flow is quite rapid.

If, on the other hand, a region be elevated and new life be thus given to the streams, there is such rapid erosion that there is a tendency to strip off the accumulated soils. Such a revival or rejuvination of the streams seems to have taken place in China. The streams are yellow with silt derived from the loess, and the waters of the Chinese sea near the great rivers are yellow from this cause one hundred miles from the coast and for six hundred miles along the coast line. The muddiness of some of the rivers of the Mississippi system and of the Amazon are in large part due to the same cause.

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*Bull. No. 52, U. S. Geol. Survey, 1889.

Whatever the origin of the upper laterite of India (see above), the lower laterite has undoubtedly been derived from it in large measure by stream action. The most reasonable explanation of the change of conditions from a residual soil producing region (if this explanation be accepted for the upper laterite) to a region of denudation is that of elevation and consequently the giving of new powers to the streams. The lower laterite occurs generally near the shore and apparently extends out to sea beyond the present shore line. Its thickness is seldom greater than fifty feet, it is always sandy and sometimes contains rounded pebbles. Human implements found with the deposit prove it to be of recent origin. Medlicott and Blanford* believe it to have been subaerially derived from the upper laterite. In part, if not entirely, it has been formed beneath the sea having been transported thither by river action, and having been raised to its present position by a recent elevation.

The importance of these suggestions in the explanation of certain geological phenomena of the past may be very great. In the Carboniferous, for instance, numerous recurrent elevations and depressions are recorded and with them great quantities of sediment were derived and deposited. In many regions great beds of clay were laid down, often having such a character as to admit of the explanation of residual origin. The remarkable development of blue, yellow, red and mottled clays in the Central Texas Carboniferous† may possibly be explained in this way. These deposits are often quite barren of fossils, indicating a very muddy sea.

The Carboniferous time was one well adapted to the accumulation of a residual soil, being apparently one of considerable moisture, much vegetation, general warmth, and of low lying lands. The elevations and depressions so well recorded must have furnished the means of removal of any such soils, either by the actual encroachment of the sea, or by the erosion of the land by subaerial agents, or by both. Such an explanation makes it easier to understand the extensive accumulations of clays in these deposits. Similar deposits in other ages may have had a similar origin. On this subject Pumpelly writes‡ "the very fine marine

*Geology of India, Vol. I.

†Tarr. First Ann. Rept. Texas Geol. Survey, 209-212.

‡Am. J. Sci., 1879, XVII, 133-144.

sediments are probably for the greater part the rapidly removed products of long-continued, protected disintegration and decomposition."

Changes in the amount of river load from the limpid stream of a low lying country, to the turbid stream flowing with rapid current over a recently elevated region covered with a residual soil, aside from the rapid accumulation of much fine sediment, must have an important effect upon the life of the region, which may be almost entirely exterminated by the incursion of the mud bearing waters. A coral fringed coast would lose its character with such an incursion and an entire change of fauna result. How many times this has happened in the past it is entirely impossible to tell at present, but a search among the geological records may very likely show many such changes which can be traced to this cause.

(f) By the Sea.

The depression beneath the sea of a country bearing a residual soil would produce similar though more widespread results. The fine sediments swept out to sea and the coarser remnants deposited nearer the point of origin would rapidly produce extensive deposits, at the same time undoubtedly changing the character of the fauna.

One recorded instance of this method of origin of sediments is all that has been found in the geological literature examined. It is so interesting that it is given here in some detail. For the complete account I refer to professor Pumpelly's paper.*

In the Hoosac mountains in western Massachusetts there is a central core of true granitoid gneiss characterized by a blue quartz. Above this and separating it from the overlying schists is a band of rock, which, though stratigraphically continuous, is widely different in its various parts. It wraps around the granitoid core or island, and on the east is a quartzite, on the north a conglomerate, while on the west it is a white gneiss. By transitional beds these pass downward into the granitoid gneiss by direct stratigraphical conformity. The conglomerate contains, besides blue quartz pebbles, many pebbles of feldspar with an unaltered nucleus bordered by a kaolinized feldspar, which, since its production, has been altered to a secondary feldspar by meta-

*The Relation of Secular Rock Disintegration to certain Transitional Crystalline Schists. Bull. Geol. Soc. Am., 1891, II, 209-224.

morphism. The feldspar cannot have been carried very far, otherwise it would have been destroyed.

There is evidence that the pre-Cambrian surface was an eroded land surface. The chief evidence of this is found in the Stamford dike of Clarksburg mountain, near Williamstown, which was, in pre-Cambrian times, eroded out below the general level of the surface. Into this the over-lying Cambrian sags, and it contains fragments of weathered dike rock.

Professor Pumpelly suggests that when the Cambrian sea encroached on the land the country was covered by a deep secularly decayed covering. The residual soil and all the finer materials were quickly removed to a distance; but the deeper zone of semi-kaolinized material was only partly worked over and was deposited near at hand. Below this was the semi-disintegrated zone now represented by the transition beds of highly foliated granitoid gneiss. This, by its weakened condition, during the subsequent extensive folding, behaved like the worked over material above, and is therefore laminated. Hence the transition and apparent conformity between the schist and granitoid gneiss. It will be seen that this is a highly plausible theory which explains, so far as is at present known, all the peculiarities of this most puzzling region; and it seems to be the only theory which will explain the facts found in the field.

These facts lead professor Pumpelly to suggest that most of the basal beds of sandstone, conglomerate and quartzite, marking the beginnings of geological periods, are produced in this way. Similar beds occur on the eastern edge of the Adirondacks where the feldspar pebbles, as in the case of the Hoosac mountains, have not been divested of their semi-disintegrated shell.

Pre-Potsdam secular decay has been described by Newton from the Black Hills, by Peale in the pre-Cambrian granite of the South Platte region in Colorado, and by others from various parts of the west. Pumpelly* has suggested a pre-Silurian disintegration of Pilot Knob, Missouri, and later explorations by mining have verified this suggestion by finding a deep zone of disintegration on the Silurian. In all these cases the transgression of the sea has in part worked over the materials of disintegration and buried the lower parts in large measure, beneath the sediment thus de-

*Geol. Survey Missouri, 1873, I, 12.

rived. Plainly, a rapid encroachment of the sea on the land is necessary to admit of such a partial working over. The ordinary movements of the land are so slow that all such loose material would be removed. Cases where the secularly decayed soil is found buried in place, or only slightly removed from its place of origin must, therefore, be relatively rare. The evidence of the existence of this kind of material during the periods of the past must, for the most part, be looked for in sediments removed some distance from their source. The mechanical and chemical constitution of such sediments ought to serve as a key to indicate their origin.

(*g*) *Summary.*

From what has been written it will be seen that secular disintegration may be an important source for the origin of sediments which may be derived from it in various ways. It may be transported to its resting place in the process of rock building, by the wind, by ice, by running water or by the sea. A country changing in climate from moist to dry is subject to ærial action of considerable uniformity and intensity, and an accumulated residual soil may thus be swept away; the change from temperate to cold, the coming on of an ice period, brings about other conditions by which accumulated soils are removed. China seems to offer an instance of the former, New England of the latter.

Changes in land elevation may admit of the accumulation of a residual soil or the removal of one already accumulated. A country long standing at a certain elevation is favorably situated for soil accumulation. The elevation of such a land gives to the streams new powers, and by this means the residual soils and disintegrated materials may be removed. The same country depressed brings the soil within reach of the waves.

Accompanying these changes there must be much destruction of life. The clear-water dwelling fauna of the shore, driven out by the appearance of mud-laden waters, is replaced by a different fauna. So there may have been alternations of faunas from this reason, as well as alternations of sedimentation, first rapid, then slow deposition.

The importance of secular disintegration along the lines above suggested is not fully understood and seems to have been generally overlooked by geologists. Secularly decayed soils exist at present and they must have existed in the past; lands have been raised and depressed and climates have changed; and such being the case it seems reasonably certain that sediments derived from secularly decayed soils must be abundant in the formations of the different ages. All the conditions for such accumulations have been present, and if the line of reasoning adopted in this essay is not fallaceous they must exist. The work of discovering evidence of them in the field yet remains to be done except in a very few cases.

NOTES ON SOME PSEUDOMORPHS FROM THE TACONIC REGION.

By Wm. H. Hobbs, Madison, Wis.

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The pseudomorphs here considered occur in northeastern Connecticut near the Massachusetts state line, within an area of crystalline rocks which are now being studied by members of the U. S. Geological Survey.

Tremolite Pseudomorphs after Salite.

The crystalline dolomitic limestone of the vicinity of Canaan, Ct., has long been known to collectors as a locality for white pyroxene and tremolite. Well terminated crystals of the former are figured in Shepard's Mineralogy.*

In a recent paper Prof. G. H. Williams has described hemihedral pyroxene crystals from Canaan and mentioned an incipient uralitization of the mineral.†

I have found pyroxene crystals to be abundant in the dolomitic limestone at numerous localities extending from Canaan northward through the valley of the Konkapot river (Mill river), at Konkapot, Mill river, Hartsville, and Monterey. They are known to the quarrymen under the name, "Jason's Teeth."

Their distribution seems to be confined to the region east of the Housatonic river. They are usually from one-half of an inch to an inch in length and stoutly columnar, but they also attain dimensions of several inches. Sometimes they are found in large

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*Vol. II, p. 133, 1835, figures 353 and 354.

†Am. Journ. Science, XXXVIII, p. 115 and Fig. 8, August, 1889.

masses forming ridges which have been described as canaanite.*

Tremolite from Canaan is mentioned in Cleaveland's Mineralogy and is common in mineral collections. The best crystals come from the Maltby quarry about three-fourths of a mile north of Falls Village, where they are semi-translucent, attaining to a breadth of a quarter of an inch or more. They are usually white but sometimes light green in color. There is also a fine radial variety from this locality having a silky lustre.

While making a reconnaissance of Canaan mountain in the summer of 1889, I came upon huge glacial boulders of impure limestone on the north flank of the mountain some distance above the exposures of limestone, and resting on a layer of till. The locality is on the coaling road about one mile south of and 330 feet vertically above the first road corner east of the junction of the Blackberry and Whiting rivers. These boulders were filled with nodules of coarse tremolite. Most of the nodules could be seen to have the form of pyroxene crystals, and several were dug out on which all the planes of the prismatic zone were well developed with the orthopinacoidal habit. In some cases the crystals show terminations by a pyramid which gives an angle of about 110° to the front, probably —2P. They attain to a length of two to three inches and a breadth of nearly two inches. Very little of the pyroxene material remains owing to a paramorphic change to tremolite.† The tremolite needles situated near the surface of the crystal usually lie with their axes in the bounding planes or nearly so, and there is also a tendency on prismatic planes to parallel orientation with the pyroxene. The arrangement of the tremolite is usually quite irregular within the crystal.

A portion of one of these pseudomorphs has been analyzed by Dr. W. F. Hillebrand in the laboratory of the U. S. Geological Survey with the results given below under I.

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*This was first thought by Hitchcock to be scapolite (Geol. Rep. Mass 2d ed., 1835, p. 315), afterwards nephrite or saussurite (Rep. Geol. Mass. 1841, p. 569). On the basis of a faulty analysis by S. L. Dana, it was thought to be a new mineral and named Canaanite (Alger's Phillip's Mineralogy, 1844, p. 89). Shepard at first thought it nephrite or saussurite (Geol. Mass., 1841, p. 569), but afterwards recognized it as pyroxene (Rep. Geol. Survey, Conn., 1837, p. 134). In Dana's System of Mineralogy (5th ed., 1868, p. 803) an analysis by Burton is printed showing the mineral to be pyroxene.

†(These specimens are No. 3186 of the U. S. Geological Survey collection from the vicinity.)

	I.	II.	III.	IV.	V.	VI.
SiO_2	57.97	60.98	60.10	55.05	51.30	58.64
Al_2O_3	.09	.10	.42 }	1.07		
Fe_2O_3	.11	.12				
FeO	.18	.19	1.00		1.60	1.83
CaO	15.05	14.64	12.73	31.35	25.21	20.25
SrO	trace					
MgO	22.45	23 62	24.31	12.53	16.47	18.83
MnO	trace		.47			
K_2O	.12	.13				
Na_2O	.20	.21				
H_2O at 100°	.03		{ .15		.39	.45
H_2O above 100°	2.57					
CO_2	1.69				5.91	
F			.78			
	100.46	99.99	99.96	100.00	100.88	100.00

I. Tremolite pseudomorphs after salite, Canaan, Ct., Hillebrand.

II. The same recalculated with water removed and CO_2 removed as $CaCO_3$.

III. White tremolite from Fahlun, Sweden (Dana's System of Mineralogy, 5th ed., 1868, p. 236).

IV. Salite from Canaan, Ct., M. D. Munn (Ibid, 6th ed., 1892, p. 356).

V. Canaanite, Canaan, Ct., B. S. Burton, (Ibid, 5th ed., p. 803).

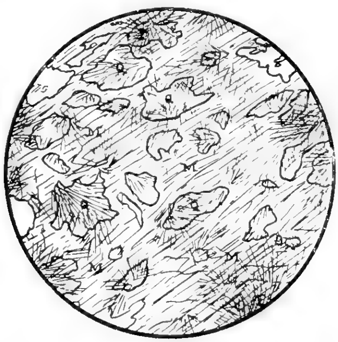
VI. The same with CO_2 removed at $CaCO_3$.

These analyses show that the alteration of the salite of Canaan to tremolite is not true paramorphism, the change involving a loss of lime and a gain of magnesia. The specific gravity of the tremolite pseudomorphs is 2.9, that of salite analyzed by Mr. Munn was 3.33.

It is quite possible that a portion of the tremolite contained in the dolomite at other localities near Canaan is derived in this way, but the manner of occurrence of much of the tremolite goes to show that it is formed directly from the recrystallization of the dolomite and its admixed quartz.

Pseudomorphs after Feldspar from Norfolk Township, Ct.

In the summer of 1889, I visited the Norfolk granite quarry, which is opened in Cambrian gneiss. There were noticed near the quarries blocks of much the same material, in which were well rounded nodules up to an inch and more in diameter. They appeared to be composed mainly of a colorless mica and feldspar mottled by grains of quartz. The mica is in scales lying along the cleavage planes of the feldspar. Sometimes no feldspar could be made out with certainty, but the direction of the mica scales indicated clearly two cleavages nearly perpendicular, corresponding with those of feldspar, and in many cases the nodule was seen to be made up of two individuals simply twinned according to the Carlsbad or albite law, dividing the nodule in halves. These twins are oftentimes very perfect, and closely resemble the simply twinned albite grains of Greylock mount-



Appearance of nodules in thin section. M Silvery Mica, Q Quartz, F Fibrolite. X 14.

ain, except that they are larger and mainly composed of mica and quartz.

Seen under the microscope in thin section, the nodules show as a background a network of colorless mica, possessing practically one orientation throughout the nodule (unless it is twinned), and inclosing quite uniformly distributed irregular areas of quartz. Penetrating the quartz and to some extent also the mica are numerous minute needles of fibrolite (See figure). No feldspar has been observed in section, yet many of the nodules doubtless contain some residue of feldspar. On separating the rock powder in the Thoulet solution a large part of the mica was removed when the solution had a specific gravity of 2.8. Owing, however, to the difficulty of making a perfect separation of the different constituents into homogeneous grains, the material continued to fall in the solution until the specific gravity was somewhat below that of quartz. As the specific gravity of the quartz would be raised by the muscovite and sillimanite attached to it, the presence of a feldspar lighter than quartz is shown.

A portion of one of these pseudomorphs has been analyzed quantitatively by Dr. W. F. Hillebrand in the laboratory of the U. S. Geological Survey, yielding the following proportions:

SiO_2	76.32
Al_2O_3	15.87
Fe_2O_3	.53
FeO	.36
CaO	.26
K_2O	4.55
Na_2O	.24
H_2O at 100°	.20
H_2O above 100	2.01
	100.34

With traces of TiO_2, SrO, Li_2O and P_2O_5.

In conversation with Prof. B. K. Emerson in 1891, he expressed his opinion that the nodules were pebbles. I have since been convinced of this from examination of them.*

The greater part of the quartz I look upon as original in the rock from which the feldspars were derived, and as essentially pegmatitic. The manner of occurrence of the quartz in areas quite regularly distributed in the mica, and the high acidity of the nodules seem to indicate this. The mica and fibrolite are regarded as due to a secondary alteration of a potash feldspar by dynamo-metamorphic agencies accompanied by a separation of quartz. The alteration of alkali feldspar into microscopic muscovite and quartz is very common.

During the summer of 1891, I visited the region northwest of the Norfolk quarry in company with Prof. Emerson. We succeeded in finding similar nodules in place in the Cambrian gneiss of Tobey hill (about two miles northwest of the quarry), from which outcrops the blocks have probably been derived.

University of Wisconsin, Madison, May 6, 1892.

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*Mr. J. E. Wolff has shown that the rounded porphyritic feldspars, which are characteristic of the "metamorphic conglomerate" and "albite schist" of Hoosac mountain and other localities in northern Berkshire, are of detrital origin. (Metamorphism of Clastic Feldspar in Conglomerate Schist, Bull. Mus. Comp. Zool., Harv. Coll., XVI, No. 10, pp. 173-183.) See also Pumpelly, The Relation of Secular Rock-Disintegration to certain Transitional Crystalline Schists. Bull. Geol. Soc. Am., II, pp. 209-224.

ON SOME BASIC ERUPTIVE ROCKS IN THE VICINITY OF LEWISTON AND AUBURN, ANDROSCOGGIN CO., MAINE.

PLATE II.

By GEORGE P. MERRILL, Washington, D. C., with analyses by R. L. PACKARD.

The prevailing underlying rock in Androscoggin, as in adjacent portions of Cumberland, Oxford, Kennebec and Sagadahoc counties, is a coarse and variable micaceous or hornblendic gneiss often including considerable thicknesses of crystalline limestone, which is colored on Hitchcock's map of the state as of Montalban age. Through this gneiss there has every where been injected a coarse highly feldspathic granite which forms the main mass of the more prominent hills or mountains of the vicinity. The so-called "David's Mountain" near Bates College in Lewiston is a good example of this granite. Contact between the molten granite and the more calcareous portions of the gneiss has given rise to various secondary minerals, including the vesuvianite and cinnamon garnets which are found at various points within the counties mentioned. Into numerous small fissures in granite and gneiss alike have subsequently been intruded basic eruptives, some of which are of interest in the present stage of petrographical knowledge and none of which have as yet received the attention they deserve.

These dikes are all small, and neither their direction nor inclination with the horizon is at all constant. Some of them are nearly vertical and run in a nearly east and west direction. Others are inclined at a very considerable angle. The original fractures through which the molten magma was protruded seem to have been very irregular, owing to the varying character of the rock masses traversed, and the material itself was too limited in amount to make its influence felt.

The dikes with which this paper has principally to deal are situated to the southward and almost within the city limits of Lewiston and Auburn and therefore on both sides of the Androscoggin river. The best exposures are on the Lewiston side in a quarry of limestone on the lower branch of the Maine Central railroad some 300 yards south of the Androscoggin mill. (Locality (1) on sketch map.)* There is here a considerable bluff of limestone facing the river, a part of which has been quarried

*This is the locality described briefly by Hunt, Chemical and Geological Essays, p. 195.

away for foundation material so that the dikes in the face of the quarry are easily accessible, but are visible nowhere else in the immediate vicinity, being covered by drift sands and clays.

These dikes, of which there are nine exposed within a distance of 250 to 300 yards vary from fifteen inches to five feet in diameter, and have apparently a nearly east and west trend, though as they are here almost vertical and exposed only in the face of the quarry, this could not be told with certainty at the time of my visit. The rocks of the dikes are, as a rule, very fine grained, compact and nearly black in color, containing only olivines, an occasional augite, or rarely a feldspar in macroscopic forms. The olivines are in some of the dikes peculiarly large and abundant, comprising at times fully one-fourth the entire mass of the rock. In several instances on a surface five cm. square not less than fifty olivines could be counted, varying in size from a pin's head to five and even ten and fifteen mm. in diameter, all fresh and glassy, or with but a narrow well defined greenish white border of serpentine. Such large and fresh olivines are very rare excepting in rocks of Tertiary or Post Tertiary age. The dikes are often beautifully banded parallel to their sides, the bands varying from two to five mm. in width and of light purplish gray and nearly black colors alternating. This feature is especially noticeable in the smaller and more compact dikes. On weathering the rock assumes a schistose structure cleaving parallel with the bandings, *i. e.* with the walls of the dikes, into scales of all thicknesses up to several inches, and often some feet in diameter.

Submitted to microscopic examination the rocks from the various dikes present close textural and mineralogical resemblances, which may be generalized as follows:—A groundmass of stout acicular idiomorphic brown basaltic hornblendes, augites with a faint violet brown or purple tinge, elongated plagioclases and the usual scattering of iron ores, carrying abundant phenocrysts of olivine, more rarely of augite and still more rarely of plagioclase. A glassy base, though not identified beyond a reasonable doubt, is strongly suggested by almost amorphous interstitial areas filled with chloritic needles and ferruginous decomposition products. The olivines in some of the dikes are highly altered, but show beautifully perfect crystal outlines. In others, as above noted, they are almost as fresh and glassy as on the day of their eruption. The brown hornblendes occur throughout only in the groundmass and in crystals of but one generation, the augites in two generations, the feldspars rarely in two, and the olivines in but one. The intratellural origin of these last is manifested by their presence in large numbers in blebs of considerable size in small offshoots from the main dikes, which are sometimes of not more than an inch in width and otherwise completely aphanitic. The olivines are not, however, equally conspicuous in all the dikes. In the first two met with going southward from the mill (the first about thirty and the second fifteen inches wide) olivine is scarcely evident to the unaided eye. In the third it is in certain parts of the dike very abundant; in the fourth scarcely evident again, and in the fifth and sixth extremely abundant and in large blebs, as mentioned above. That, however, the rocks are essentially the same and must be portions of the same magma, is evident from their similarity in mineral, as well as chemical composition.

There are certain differences in the slides from different dikes that are worthy of note. The larger dikes, as would be expected, show as a rule a more granular structure, though this is not a universal rule. In the second dike below the mill (28525)* the idiomorphic nature of the hornblendes and augites of the groundmass is less distinctly marked than in the first. A sample from this dike yielded Prof. Packard 40.26% SiO_2. The third dike (28526) is a typical camptonite, and excepting the numerous large olivines, is indistinguishable in the section from the original diabase of dike No. 1, at Campton, New Hampshire, as described by Hawes.† The fourth dike, three feet wide, (28527) is quite similar, but the slides show in places a structure bordering upon ophitic. The fifth, 2 feet wide (28528), shows also a tendency toward an ophitic structure and there is a much less distinct separation of the minerals into individuals of two generations. The olivine is here the only mineral porphyritically developed. The sixth dike, 2½ feet wide (28529 and 39194), is the most striking of all, and the one to which owing to its richness in olivines my attention was first attracted.‡

In the hand specimen this is a dense dark gray aphanitic rock

*The numbers given are those of the specimen as entered in the Museum catalogue.

†Am. Jour. Sci., 3d, XVII, 1879, p. 147.

‡This is the rock referred to by Prof. Kemp in his paper "On the Dikes Near Kennebunkport, Maine." AM. GEOLOGIST, March, 1890, p. 138.

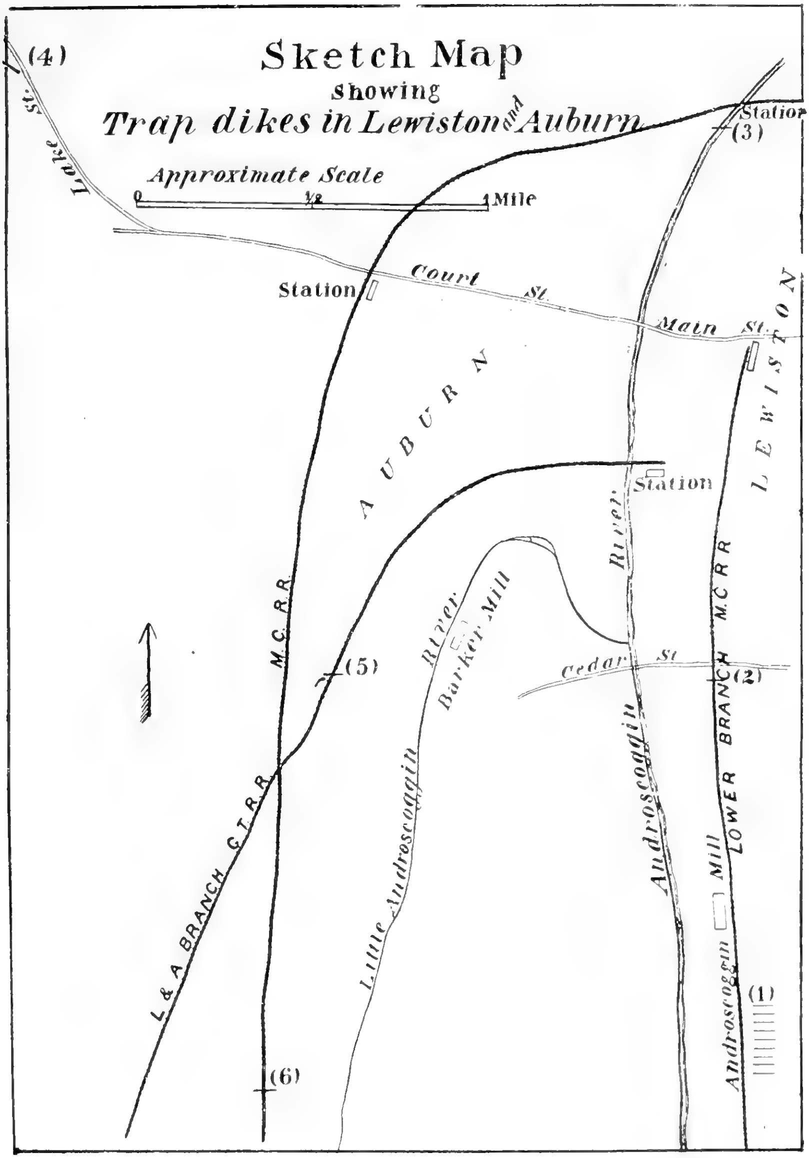
with abundant large (4 to 8 mm.) phenocrysts of augite, olivine and plagioclase, the olivines being most abundant. Like the true camptonites it shows under the microscope a dense groundmass of minute brown hornblendes, augites, plagioclase and iron ores, all in idiomorphic forms, throughout which are scattered the phenocrysts of olivine, augite, and plagioclase above noted.

A search for similar dikes elsewhere in the vicinity resulted as follows:—

At the Cedar street crossing of the lower branch of the M. C. R. R.—a few squares above the mill and to the northward—(locality (2) on sketch map) a dike 5 feet in width was found, consisting of a compact dull dark gray rock with an abundant sprinkling of small olivines. Under the microscope the mineral nature of the rock (28523) was found to be quite similar to the others mentioned, excepting that augites prevailed in excess of hornblendes in the groundmass. The structure was also quite variable in different sections, in some cases being decidedly porphyritic, as in the camptonites, or again ophitic as in normal diabase. An abundance of secondary calcite here, as in the other dikes, obscures everything. There is no doubt but that this belongs to the same series of dikes. Still further northward, just below the Maine Central railroad bridge over the Androscoggin river, and running nearly parallel with the bridge is a dike some five feet in width of a dense dark greenish rock (28534) which under the microscope shows the ophitic structure of ordinary diabase, and which yielded Prof. Packard 49.75% $Si\,O_2$. This dike is covered by overlying rocks and soils on either shore and may be seen to advantage only in the river bed and at low water. (Locality (3) on map). This is presumably the dike mentioned by Jackson* as having a direction of N. 80 W., S. 80 E., though the width as given by him is but 2½ feet.

Going southward on the Auburn side of the river the first dike encountered was on the property of L. Merrill, Lake street, above Fern. (Locality (4) on map). This was in granite and but three inches in width. The rock is dark gray, strongly banded parallel with the sides of the dike in gray and black colors and showing in the hand specimen simply a compact aphanitic ground without crystalline secretions of such size as to be determinable by the unaided eye or pocket lens. Under the microscope in thin sec-

*Geol. of Maine, 3d Ann. Rep., 1839, p. 191.


Sketch Map
showing
Trap dikes in Lewiston and Auburn
Approximate Scale
0
½
1 Mile
(4)
Lake St.
Station
(3)
Station
Court St.
Main St.
AUBURN
LEWISTON
Station
River
M.C.R.R.
LOWER BRANCH M.C.R.R.
Barker Mill
Little Androscoggin River
(5)
Cedar St.
(2)
L & A BRANCH G.T.R.R.
Androscoggin
Mill
Androscoggin
(1)
(6)

tions (28519) it shows a dense irresolvable base, the true nature of which is badly obscured by calcite and ferruginous decomposition products, but which was once evidently a glass. Throughout this base are thickly scattered abundant acicular plagioclases, iron ores in granular and gratelike forms and occasional larger rounded blebs of more or less serpentinized olivines. Hornblendes or augites if ever existing, have been obliterated by decomposition. This rock yielded Prof. Packard 39.40% $Si\ O_2$. No other dikes, of which this might be considered an offshoot, were discovered in the vicinity.

Going still farther south two small dikes, one 15 inches and one 3 feet wide, were found exposed in the railroad cutting of the Lewiston and Auburn railroad on the west bank of the Little Androscoggin river nearly opposite the Barker cotton mill. (Locality (5) on map). These show a structure in every way identical with those first described south of the Androscoggin mill and from their position (nearly due west) there seem good reasons for assuming them to be a continuation of the Cedar street dike in Lewiston. A complete analysis of one of these rocks (28531) is given on p. 54. In a cutting of the Maine Central railroad, south of the Taylor Brook crossing, and about a mile below the city of Auburn occurs still another dike about 12 inches in width (locality (6) on map). This rock (28532) in the thin section is indistinguishable from Hawes, dike 1, (diabase) at Campton Falls, New Hampshire.* It yielded Prof. Packard 39.46% $Si\ O_2$ and is presumably a continuation of the dikes south of the Androscoggin mill on the Lewiston side of the river.

Farther to the west, between the well known tourmaline and lepidolite locality, fancifully known as "Mount Tourmaline" and Stevens mill, is another dike five feet in diameter (28658) which shows also a camptonite structure and composition. It is to be noted, however, that slides in the Museum collection from other dikes having the same trend, but lying to the northwest, near Taylor pond, are normal diabases and ophitic in structure.

The next dike met with, traveling south along the M. C. R. R., is found just before reaching Danville junction. This is a large dike of normal olivine diabase (35056) which yields some 46% $Si\ O_2$.

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*Dr. Hawes' original specimens and thin sections are in possession of this department.

Analyses of samples from the olivine rock, dike 6 below the Androscoggin mill in Lewiston (39199), and the 12 inch dike from the cutting in the Lewiston and Auburn railroad in Auburn (28531) yielded Prof. Packard results as below. For purposes of comparison are given (III) the analyses of dike No. 1, at Campton, New Hampshire, as given by Hawes.* (IV) of the Montreal diorite as given by Harrington,† and (V) and (VI) camptonites from Proctor and Fairhaven, Vermont, as given by Kemp and Marsters.‡

	I.	II.	III.	IV.	V.	VI.
SiO_2	39.32	41.15	41.63	40.95	41.00	43.50
TiO_2	1.70	1.60	3.95	3.39		
Al_2O_3	14 48	13.51	13.26	16.45	21.36	17.02
Fe_2O_3	2.01	2.32	3.19	13.47	13.44	13.68
FeO	8.73	8.63	9.92			
MnO	0.71	1.28	.27	0.33		
CaO	8.30	8.75	8.86	10.53	10.40	8.15
MgO	11.11	10.09	7.31	6.10	3 85	6.84
K_2O	0.87	1.22	3.32	1.28	1 31	2.84
Na_2O	3.76	3.21	2.49	4.00	2.86	2.84
P_2O_5	0.61	.61		0.29		
CO_2	5.25	5.54	5.20			
H_2O	2.57	3.05	1.35	(Ign)3.84	5.00	4.35
	99.42	100.96	100.75	100.63	99.22	99.40

From the above it appears that in the immediate vicinity of Lewiston and Auburn are two series of small and geologically speaking insignificant dikes, both having essentially the same trend (so nearly so that they were supposed at the time these observations were made, (1883), to belong undoubtedly to the same system) one of which is normal diabase while the other, including nine or more lying almost within the southern outskirts of the two cities, must be referred to the lamprophyrs, or if a specific name is demanded, may be called camptonites as the term is used by Rosenbusch. There are objections to this. In all of them augite occurs both as phenocrysts and as a constituent of the groundmass, and must be considered as of greater genetic importance than the hornblende. There is moreover an almost constant tendency toward an ophitic structure as displayed in basalts and diabases.

Just how much weight in the matter of classification is to be attached to micro-structural features, it is perhaps as yet too

*Am. Jour. Sci., 3d, XVII, 1879, p. 147.

†Rep. Geol. Survey of Canada, 1877-78, p. 44 G.

‡Trans. New York Academy of Science, vol. XI, 1891.

early to say. In the writer's opinion neither these nor the fact that up to date such rocks may have been found occurring only in dikes is alone of sufficient importance to warrant the introduction of new names into a branch of science already over-burdened. We must not, however, lose sight of the fact that in addition to the above characteristics (which may or may not prove constant) we have here a peculiarly basic magma standing intermediate between the diabases and peridotites, and which, as a plutonic rock, can be relegated to none of the older groups. As a convenient temporary term the name camptonite as given by Prof. Rosenbusch is perhaps as good as any. The fact that the dikes so far described, are in all cases extremely narrow—from 3 inches to 5 feet—is, to say the least, interesting. That the structure of the rock is quite independent of the size of the dike is however shown by the occurrence in the same vicinity of equally small dikes which are normal diabases in both composition and structure.

It is to be noted that chemically the rocks might be considered as members of the monchiquite group, from which however they are excluded by the uniform presence of plagioclase feldspars.* The high percentage of magnesia, a necessary consequence of the abundant olivine, is also worthy of note as indicating a close chemical relationship with the peridotites.

Thanks are due Mr. L. H. Merrill, chemist at the Maine experiment station, by whom many of the samples were collected and sections cut, as well as preliminary analyses made.

National Museum, April, 1892.

In his inaugural address, before the Royal Society of Canada, the President, Abbe J. C. K. Laflamme, of Laval University, Quebec, gave an extended account of the life and labors of the late Dr. T. Sterry Hunt, who had been one of the members of the society from its inception.

*Compare analysis II above, with V as given by Prof. Rosenbusch in Min. u. Pet. Mittheilungen VI, Heft. XI, 1890, p. 464.

ON THE OCCURRENCE OF TYPICAL CHÆTETES IN THE DEVONIAN STRATA AT THE FALLS OF THE OHIO AND LIKEWISE IN THE ANALOGOUS BEDS OF THE EIFEL IN GERMANY.

PLATE III.

By Dr. C. Rominger, Ann Arbor.

The numerous forms formerly comprehended under the name *Chætetes*, by considering merely the general external resemblance of the fossils with the one described by Fischer under the name of *Chætetes radians*, were found by more accurate microscopic examination to exhibit many important differences in their structure.

The majority of this mixed assembly could be placed under *Monticulipora*, a generic group proposed by D'Orbigny; another part was found to correspond with the forms described by Lonsdale under the name *Stenopora;* for still others the erection of new genera was deemed necessary, and only a very small number of them actually corresponded with *Chætetes radians*, the type of the genus.

Chætetes so restricted, like *Stenopora*, was unknown in strata older than the Carboniferous period, but in the subjoined pages I am going to describe representatives of *Chætetes* from the Devonian at the Falls of the Ohio and from the contemporaneous beds of the Eifel in Germany.

Before proceeding with the description it will be desirable, first, to define the characters distinguishing *Chætetes* from *Monticulipora*, *Stenopora* and related genera.

Common to all of these is the composition of their colonies of small elongated tubules which are in their whole extent intimately grown together; the channels of these tubules are intersected by more or less numerous transverse diaphragms, and are not in communication with the adjoining tubules by lateral pore channels as they occur in the favositoid tribe, whose general structure exhibits so many points of resemblance with *Chætetes* that even today some naturalists not only consider *Chætetes* as a subordinate member of the favositoid family, but have described characteristic *Chætetes* forms under the name *Calamopora* which is a synonym of *Favosites*.

The above mentioned structural characters common to the various generic groups under consideration are subject to certain modifications constituting the distinctive marks upon which the separation of *Chætetes* from *Monticulipora*, *Stenopora*, etc., is based. In *Monticulipora* and *Stenopora* the walls of the intimately united tubes are either distinctly double, exhibiting a central demarcating line between the contiguous walls, or this line is obliterated, but each of the tubes is in the immediate circumference of its orifice surrounded by concentric rings of darker shade than the lighter colored intermediate sclerenchymal mass, which plainly indicates the original independence of each of the anchylosed walls.

In only a small subdivision of the *Monticulipora* group are the walls so thin that it is practically impossible to demonstrate their duplicity.

Stenopora has double walls like *Monticulipora*, but among other differences the periodical swelling and contraction in the thickness of the walls constitutes its principal generic peculiarity. In *Chætetes* the walls intervening between the tube channels are comparatively thick, but appear to be common to the contiguous channels; it differs further from the other generic groups by the development of irregularly disposed longitudinal crests within its tubes. Their number is variable; in some of the tubes no crests are observable, in others one, or two, or even three and four may be present which indentations cause considerable irregularity in the shape of the orifices. Another essential point of difference between *Chætetes* and the other forms under comparison is said to be the multiplication of its tube channels during the progress of growth by a division of the older tubes, while in the other genera the tubes are multiplied by production of lateral gemmæ. This assertion is at least not fully correct; on the one hand I have before me sections of typical *Chætetes* in which a multiplication of the tubes by gemmæ, sprouting from the edges of the tube walls, is plainly exhibited; on the other hand an indubitable instance of a division of the older tube channels in two, or several, never occured to me, but not very rarely I have seen in transverse sections the longitudinal crests project so far into the lumen of the tubes that sometimes two opposite crests almost came in contact, which case might be apprehended as a not fully accomplished stadium of the division of a tube.

The above mentioned want of differentiation in the walls of the adjoining tube channels, does not imply their perfect homogeneity; in reality every tube orifice is bordered by a circle of nodules resembling in thin sections the cross cut acanthopores of a *Monticulipora*, but never showing a central perforation as they sometimes do.

The size of these nodules differs considerably in the same circle; some three or four are larger than the other intermediate ones and constitute the upper termination of the before described longitudinal crests indenting the orifices; the other smaller ones cause no perceptible indentations of the tube channels, but they are perceptible as delicate longitudinal striæ (Wandstrænge) on the faces of vertically cleft specimens, and better still in thin, longitudinal sections. The walls are actually composed of laterally anchylosed vertical columelles, which, counting the larger and smaller ones, amount to from ten to fifteen in each circumference of a tube.

The specimens of *Chætetes radians* from Miatschkowa Govern. Moskau, which I have had occasion to examine, are of coarsely crystalline grain and do not allow of observing all the details of structure; much plainer are they exhibited by specimens of *Chætetes milleporaceous* from different localities in Indiana, Illinois and Kentucky, and in still greater distinctness all these structural particulars may be observed in the Devonian species found at the Falls of the Ohio and in the Eifel mountains.

Noteworthy yet is the frequent development of morticules on the surface of *Chætetes* specimens, which are occupied by tube orifices of larger size than the rest. In addition to the other points of structural similarity, these monticules seem to me a confirmation of the close relationship existing between *Chætetes* and *Monticulipora*.

After these preliminary remarks I will enter on the special description of the Devonian species of *Chætetes*.

The specimens from the bed of the Ohio river I had collected a number of years past; on account of their external resemblance I had identified them without closer examination with a similar form abundantly found in the limestone formation of Sandusky and Kelley's Island, and provisionally labelled them with the name *Chætetes ponderosus*. Later, Prof. Hall figured in one of his publications a form perfectly corresponding with the Sandusky specimens, and accordingly I adopted that name in place of the one given by me provisionally.

Only recently, when I happened to look over these specimens, I noticed that some differences existed between those from one locality and those from the other, and when I came to examine them microscopically, I found to my surprise more important differences in their structure than I had expected to find.

The mode of growth in both is about the same, forming bulky convex masses or undulating thick tabular expansions, consisting of sub-parallel closely united tubules of about $\frac{1}{3}$ of a millimeter in width; the surface exhibits low rounded monticules, on which orifices of somewhat larger size than the others present themselves.

In vertical fractures through such colonies is seen their composition of a number of concentrically superimposed successive layers, each of which represents a certain period in the growth, and a preceding and subsequent interruption of it. In this respect an obvious difference exists between the Sandusky and Louisville specimens. The concentric layers of the latter are merely indicated by an incrassation of the tube walls on that limit without an interruption in the continuity of their channels, while in the Sandusky form each concentric layer consists of an independent set of new tubes, which start with procumbent ends on the top of the orifices of a subjacent layer and soon after rise into an erect position. These procumbent basal ends of the new set of tubes frequently are consolidated into a continuous lamina, which under favorable circumstances allows a separation from the subjacent belt of tubules, presenting a wrinkled surface, very much like the laminar surfaces we can observe on splitting the double leaved expansions of a Ptilodictya or Stictopora. Such periodical interruptions in the growth occur at very variable intervals; in the same specimens the thickness of such a layer may not exceed two millimeters, subsequent ones may measure four and five millimeters, and some over an inch before a new disturbance in the growth commences. On cleaving such specimens vertically the tubules readily separate so as to present their angular outlines intact and the surface partly covered with wall substances which on its sides exhibits delicate transverse wrinkles of growth, besides stronger corrugations becoming most conspicuous in the angles of junction between the neighboring tube channels. The specimens from Louisville, in distinction from the Sandusky specimens, never exhibit such transverse rugosities; their tubes join under remarkably straight edges, but on the other hand, they show a plain longitudinal striation, of which on the Sandusky form not a trace can be perceived.

Comparing microscopical sections of the two forms, their structural diversity is still more clearly exhibited.

Transverse sections of the Sandusky specimens and of similar ones from the Helderberg group at Long lake near Alpena, present thin walled polygonal orifices $\frac{1}{3}$ of one millimeter in diameter and somewhat larger ones crowded around the monticules. In the angles between the tubes a small number of triangular or quadrangular cell spaces may be noticed, which must be taken for the young ordinary tubes. Besides these, also acanthopores are observable in distantly scattered position. In every one of the successive layers the tubes are near their upper termination subject to a slight incrassation, which thickened portion exhibits under the microscope its diaphanous sclerenchymal mass dotted by numerous dark punctations disposed in a double row around the circumference of the orifices. If sections are not thin enough for good transparency, these densely crowded punctations could sometimes be mistaken for cross bars extending from one side of a wall to the other, or for the channels of connecting pores, but in sections, sufficiently thin, it becomes plain above all doubt, that these dark dots are isolated punctiform, and never traverse the entire thickness of the walls. This punctation of the substance of the tubewalls, noticeable in cross sections, is also in longitudinal sections dimly perceptible, but only the incrassated wall portions show this dotted structure; the intersected thin-walled parts of the tubes do not.

In all the examined specimens were found developed transverse diaphragms, unequally distributed and rather remote in position.

Summing up the points of the preceding description, this form (Hall's *Chætetes tennis*) corresponds in all particulars with Nicholson's proposed subdivision of *Monticulipora*, termed *Monotrypa* excepting in the presence of a few acanthopores, said to be missing in *Monotrypa*. But this arbitrary restriction of generic limits, which is not fully proved even with regard to the type form *Monotrypa undulata*, of which I have specimens exhibiting distantly scattered acanthopores, does not detain me from associating the described form with its nearest family relations and to introduce it under the name *Monotrypa tennis* Hall sp., since the name *Chætetes* as now defined is no longer applicable in the case. As however the Louisville specimens, about to be described, fully correspond, in their structure with *Chætetes*, my formerly used provisional designation *Chætetes ponderosus* can now be permanently settled upon them.

Their external mode of growth has already been mentioned. The width of the rounded polygonal tube orifices, is, as in the former, about one-third of a millimeter and of the larger ones, on the monticules, about half a millimeter; the intervening walls are stout, and not formed of a homogeneous mass of sclerenchyma, but obviously show their composition of a circle of solid vertical tissue columelles of alternately smaller and larger sizes. These columelles are intimately united with their side faces into closed channels with simple walls common to the contiguous cavities.

According to the different sizes of the tubes, from twelve to sixteen of such columelles may be counted in the circumference of an orifice. The larger columelles generally occupy the angles of the tubules, the smaller ones the intermediate part of the walls. Cross sections of the columelles under the microscope appear exactly like intersected acanthopores, as they present themselves in tangential sections of some Monticulipora species, but none show a central perforation like some of these do in *Monticulipora.* The entire thickness of the walls is occupied by these columelles, the larger of which cause a slight indentation of the margins, but in this species scarcely ever such strong crest-like projections occur as we observe them in the tubes of *Chætetes milleporaceus*; otherwise, however, the longitudinal striation of the tube walls, corresponding with their columellar structure, is much more plainly visible in thin sections, and even microscopically on cleavage faces of the Devonian form, than ever it occurs in specimens of *Chætetes milleporaceus.*

Transverse diaphragms, rather remote in position, are usually developed, but in some specimens I could not discover their presence.

From the Devonian limestones of the Eifel I have two different species. One of these I collected myself 50 years past in the vicinity of Gerolstein; it grows in strumose convex masses, and is preserved in a porous, granular limestone, with dull fracture. The fossil itself is likewise composed of a similar granular calcareous material, wherefore the more delicate strúctural details are somewhat obscured. Still, in thin sections, the principal features of the species are sufficiently plain for recognition. Width of the tubes, one-third of a millimeter; shape of the orifices quite irregular, somewhat rounded and longer in one direction than in the other, with conspicuous indentations of the cavities by two, three, or four of the larger vertical crests. The intermediate smaller columelles, though plainly recognizable in cross sections, do not cause indentations of the margins. In longitudinal sections, the striated surface of the walls, the intersection of the tubules by moderately numerous transverse diaphragms, the concentric superposition of new layers without an interruption in the continuity of the tubules, and the multiplication by lateral or marginal gemmæ, are all features readily observable.

The material at my disposal is not sufficient to determine whether the second form, which I obtained from Prof. Schlüter in Bonn, is really a different species. It grows in thick, flat expansions, which have been described and figured by Prof. Schlüter under the name *Calamopora piliformis.* I refer to his own figures and explicit descriptions, from which the identity of his species with *Chætetes* becomes evident before one subjects the fossil itself to a scrutinous examination.

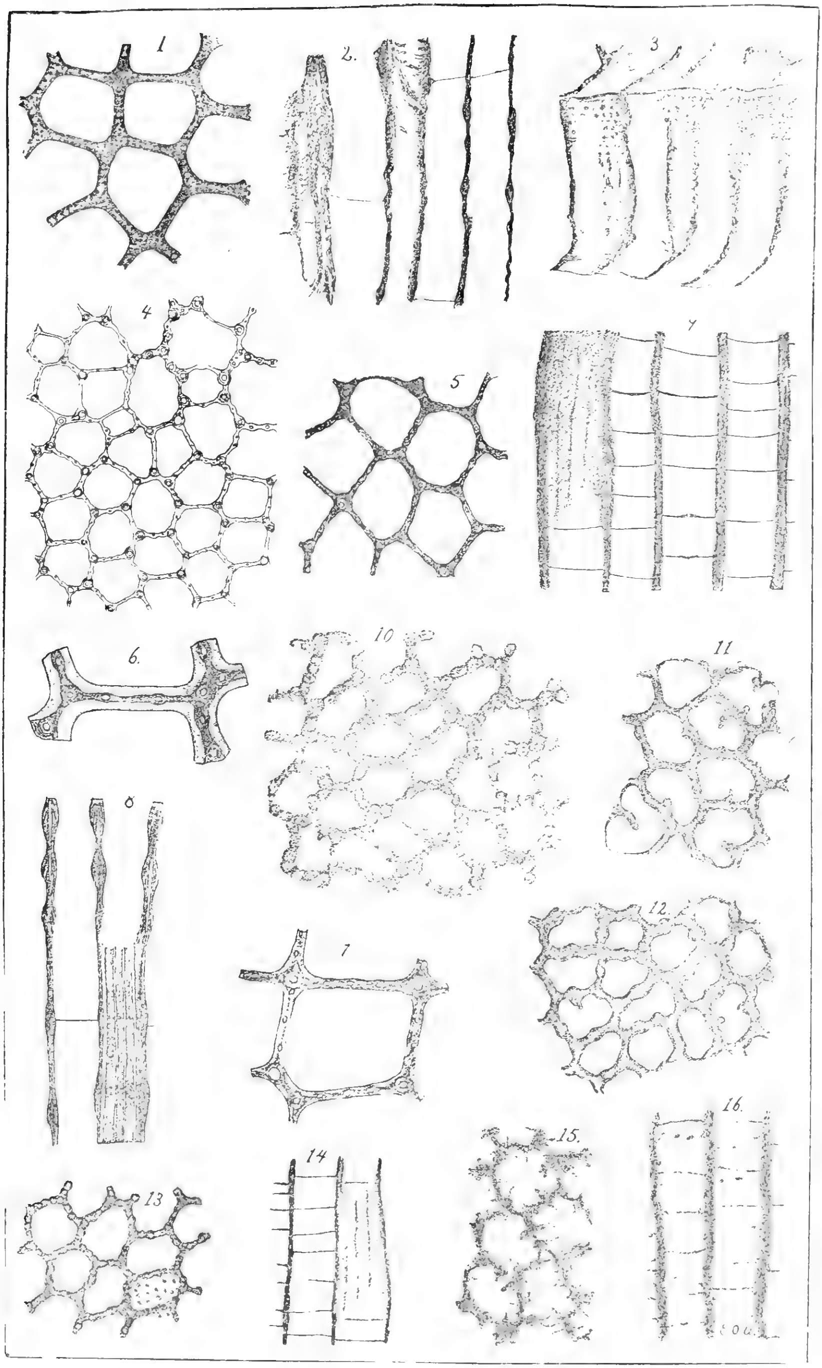
The margins of the irregularly polygonal, somewhat rounded orifices are indented by two or three, but not rarely by four and five, crest-like projections, and the intermediate portion of the margins shows the outlines of smaller columelles taking part in the formation of the walls. The tubules, one-third of a millimeter wide, ascend almost parallel with each other from the base of the expansions to their upper surface without an obvious interruption except by numerous transverse diaphragms, distant a little more than one tube diameter. Not a trace of lateral connecting pores can be discovered, and as Prof. Schlüter is fully aware of that fact, I feel somewhat surprised, that he unreservedly places this form under the genus *Calamopora*, a synonym of *Favosites.*

EXPLANATION OF PLATE.

Figs. 1-3, MONOTRYPA TENNIS Hall, sp.

1. Small portion of tangential section, × 35, showing structure of walls and one of the acanthopores.

2. Portion of vertical section, × 18, showing an acanthopore, the beaded structure of some of the walls, and several diaphragms.



DEVONIAN AND CARBONIFEROUS CHÆTETES.

3. Another portion of a vertical section, × 18, showing the entire thickness of a narrow layer of tubes, and the minutely punctate character of their walls.

Figs. 4-8, CHÆTETES PONDEROSUS, n. sp.

4. Tangential section, × 18, with part of a cluster of large cells.

5. Portion of another section, × 28.

6 and 7. Walls of two tubes, × 50, showing minute structure, the first with the wall thick, the second below the average in thickness.

8. Vertical section, × 18, showing structure of walls of two tubes The constrictions of the walls are nearer each other than usual.

Figs. 9-10, CHÆTETES, sp. undet., from the Eifel of Germany.

9 and 10. Vertical and transverse sections, × 18.

Figs. 11-14, CHÆTETES MILLEPORACEUS Ed & H.

11, 12 and 13. Small portions of three transverse sections, × 18, showing variations in wall-structure.

14. Two tubes of a vertical section, × 18, showing wall-structure and arrangement of diaphragms.

Figs. 15-16, CHÆTETES PILIFORMIS Schlüter, sp.

15 and 16. Small portions of transverse and vertical sections, × 18.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Tertiary Plants from Bolivia.—In the Trans. Amer. Ins. M. Es. (June, 1892), Prof. N. L. Britton describes a number of Tertiary plants collected by Dr. A. F. Wendt at the silver mines of Potosi. The plants were found in a fine-grained sandstone which, according to Prof. Kemp, who made a microscopic examination of the rock, is undoubtedly volcanic glass and pumice. The fossils are very fragmentary, and the author is inclined to the opinion that some of the species represented are the same as living forms. *Myrica banksivoides* Engelhardt, *Cassia chrysocarpoides* Engl., and *C. ligustrinoides* Engl., appear to be the most common. Ten new species are described and seventy-nine figured, of which ten are undetermined.

Geology of Maryland.—Johns Hopkins Univ. Cir. No. 95, pp. 37-39. Under the auspices of Drs. G. H. Williams and W. B. Clark, the university geologists made seven excursions in the vicinity of Baltimore, and a short notice of the results is given in the present paper.

For geological work this university is perhaps more favorably situated than any other institution. The state presents all the periods from the Archæan to the Tertiary, and much of this is within a short journey of Baltimore. Perhaps the most interesting excursion from a palæontological point of view was that to Fort Washington, on the Potomac river. A section is here most beautifully exposed and consists of Pleistocene 8 ft., Eocene 12 ft., Cretaceous 20 ft., Potomac 55 ft. The first and last being at this point non-fossiliferous. No new evidence is given regarding the position of the Potomac group.

Cuprocassitterite: A new mineral.—(Trans. A. I. M. E. Feb. 1892). Mr. Titus Meke describes an apparently new tin mineral, which he discovered at the Etta mine, Black Hills, S. Dak. He gives the formula as 4 $SnO_2 + Cu_2 Sn (HO)_6$, containing Sn 60 p. c., H_2O 8 p. c. Hardness 3, Sp. Gr. 5. Gives Sn and Cu reactions with soda. Dissolves in acids with separation of SnO_2. The author advances the opinion that the ancients may have used this mineral, being of comparatively easy reduction, in the manufacture of their bronze.

Bohemian Garnets: Mr. George F. Kunz (Trans. A. I. M. E. Feb. 1892) gives the results of his visit to the garnet district of Bohemia, situated sixty kilometers northwest of Prague. The region is one of alluvium and diluvium resting upon the Cretaceous (Pläner-kalk). Phonolite and basalt penetrate the strata. The garnets, which are of the pyrope variety, are found loose in the soil, in the diluvium, and embedded in the serpentine. The lower layer of the strata is cut away, the upper ones being thrown down, after which the stones are separated with water. A quantity of vertebrate remains have been found in the diluvium by Dr. Parek. They are exhibited at Trebnitz, and comprise *Elephas*, *Rhinoceros*, *Antelodus*, *Rangifer*, *Cervus*, *Equus*, *Bos*, *Ursus* and *Sus*. From a financial point of view, Mr. Kunz mentions the fact that in 1890 these "diggings" produced uncut garnets to the value of 80,000 guilders. The average daily pay of each worker is about 38 cents.

Eleolite-Syenite of Litchfield, Maine, and Hawes' Hornblende-Syenite from Red Hill, New Hampshire. By W. S. Bayley. Bulletin, G. S. A., vol. iii, pp. 231-252, with a map and microscopic sections; June 4, 1892. Two varieties of eleolite-syenite are described in this paper, one of which the author names *litchfieldite*, from the township of Maine in which it is found. The second, which is a more nearly normal variety, comes from Red hill in Moultonboro, N. H., near the northwest end of lake Winnipesaukee.

The System of Mineralogy of James Dwight Dana, 1837-1868.—Descriptive Mineralogy. Sixth edition, by Edward Salisbury Dana. New York; I. Wiley & Sons, 1892, pp. 1134 + 53, figs. 1400.

More than a score of years have passed since Prof. Dana, the elder, issued his fifth and last edition of his system of mineralogy. We are now glad to welcome this new edition, for the advance in this science, even in the past ten years, has been remarkable; still, his system in this country has not been abandoned. Besides many new additions, other changes of much importance have been incorporated in this sixth edition. In the mathematical portion, the angles of the various species constitute an important feature. Many of these angles have been recalculated and are now published in new form. Many new chemical analyses are given, adding much to the value of this great work.

It is evident that professor Dana does not believe in an unnecessary increase in new species, and it is also evident that his judgment in this respect is correct, for there are too many workers who are ready, at the least pretext, to create new species. This undoubtedly has arisen from too hurried examination. If new names are *absolutely* necessary, let them be provisional until further investigations prove their right to become permanent. The learned author, much to his credit, is only able to recognize between 800 and 900 species. We can agree with professor Dana in the statement that many apparently new species, if studied with sufficient care and comparison, would undoubtedly fall under some old species and form varieties thereof, and of this the present work will be a constant reminder.

The volume is a credit to American mineralogy, and the system of Dana will continue to be, as in the past, the chief guide and authority for English-speaking students, at least in America.

The Mannington oil field and the history of its development. By I. C. WHITE. Bulletin of the Geological Society of America, vol. iii, pp. 187-216, with map and sections; April 15, 1892. The district here described lies in Marion and Monongalia counties, W. Va., on the Monongahela river. In each of the three sections noted at Mount Morris, Mannington, and Fairview, the oil wells pass through the whole thickness (1,900 to 2,000 feet) of the Carboniferous system, from the Permian or Dunkard Creek series to the "Big Injun" or Mount Morris oil sand, which belongs to the horizon of the Pocono sandstone, the lowest of the Carboniferous strata. The paper contains also a very interesting history of the development, chiefly by Profs. White and Orton, of the "anticlinal theory" of reservoirs of oil and natural gas, and of its successful application to the discovery of new locations for oil wells in the Mannington district.

Fossil plants from the Wichita or Permian beds of Texas. By I. C. WHITE. Bulletin, G. S. A., vol. iii, pp. 217, 218; April 15, 1892. A collection of nineteen species of plants from the Wichita formation in Texas, which is regarded by Dr. C. A. White and Prof. E. D. Cope as certainly of Permian age on the evidence of its invertebrate and reptilian remains, is found to comprise eighteen species that occur in the Dunkard Creek series of West Virginia, southwestern Pennsylvania, and southern Ohio. The determinations of these plants were made by Prof. W. M. Fontaine, who, with the author of this short paper, referred these beds to the Permian, on the basis of their fossil flora, fourteen years ago.

Notes on the Geology of the Valley of the middle Rio Grande. By E. T. DUMBLE. Bulletin, G. S. A., vol. iii, pp. 219-230; April 22, 1892. The portion of the Rio Grande valley here described, from the mouth of San Felipe creek, near Del Rio, to Webb Bluff, near the south line of Maverick county, has a length of about 80 miles. The elevation of Del Rio is 973 feet, and the descent thence to Eagle Pass and Webb Bluff is about three feet per mile of direct distance, or approximately two feet per mile along the meandering course of the river. A slight southeastward dip, estimated to be about 100 feet per mile, brings successively newer beds into view as one travels down the valley, from the *Arietina* clays of Lower Cretaceous age at Del Rio to the Eocene beds of Webb Bluff. The thickness of the Upper Cretaceous strata appears to be about 7,800 feet. Overlying the eroded surface of these formations are gravel deposits, often cemented by calcareous matter and passing into limestone, named the Reynosa beds, which contain fresh-water shells, as *Bulimus alternatus* Say, and are thought to be a phase of the Lafayette formation.

A revision and monograph of the genus Chonophyllum. By WILL H. SHERZER. Bulletin, G. S. A., vol. iii, pp. 253-282, with one plate; May 24, 1892. Twelve species of this genus of Paleozoic corals are recognized, two of them being described for the first time. Ten are North American, and two (including one of the new species) are European. The genus existed through the Upper Silurian era and the Corniferous and Hamilton divisions of the Devonian, its culmination being in the Upper Helderberg epoch.

PERSONAL AND SCIENTIFIC NEWS.

THE ROYAL SOCIETY OF CANADA held its regular annual meeting in the Parliament Buildings at Ottawa, Ontario, from May 31st to June 2d.

The four sections adjourned to different apartments for the reading and discussion of papers.

In Section III, CHEMISTRY AND MINERALOGY, Professor E. J. Chapman, of the University of Toronto, read the following two papers: *On a New Form of Application-Goniometer. On the Mexican Type in the Crystallization of the Topaz, with some Remarks on Crystallographic Notation.*

In Section IV, GEOLOGY AND BIOLOGY, Mr. G. F. Matthew, of St. John, N. B., delivered his *Presidential Address "On the Diffusion and Sequence of the Cambrian Faunas."*

In this address an attempt is made to distinguish the littoral and warm-water faunas of the Cambrian age from those which mark greater depths of the sea and cooler water.

On the hypothesis that species capable of propagating their kind in the open sea would spread rapidly to all latitudes where the temperature of the sea was favorable, such forms as the graptolites are taken as fixed points in the successive faunas. The relation to the graptolites is noted of various species of other groups of animals, as they occur in different countries. It thus appears that several genera appeared first in America and afterwards spread to Europe.

On the other hand a very close connection appears to have existed between the Cambrian faunas of the north of Europe and those of the Atlantic coast of North America. Hence it is inferred that the temperature of the sea of these two coasts was similar, and the connection between them direct and unimpeded. Equal temperatures in these different latitudes would be maintained by a cold current flowing from the North European to the North Atlantic coast. The evidence available seems to point to a migration of the American species by a route to the west and north of the main part of the Atlantic basin.

Mr. Matthew also contributed another paper entitled: *Illustrations of the Fauna of the St. John Group, No. VII.*

This is the final paper on this subject and treats chiefly of the fauna of the highest horizon in the group. It was accompanied by a list of all the species of the St. John group, showing the several horizons at which they have been found.

There was an index to the whole series of the author's papers on the species of this group; those of the Basal series which underlies it, and those described by the author from the Cambrian rocks of Newfoundland.

Besides the species from the highest horizon of the Bretonian Division (Div. 3) which formed the main subject of this paper, a few others from near the base of this division were described. Among these are a small Camarella and Strophomena, also small, which is perhaps the oldest known being from near the horizon of *Parabolina spinulosa.*

From the highest horizon itself the species are of the age of those of the Levis shale, or thereabout, as shown by the graptolites found here. There are several orthids, some of which are identical with, or are varieties of species of the Levis limestone described by Billings. The few trilobites known are of Cambrian types and include a *Cyclognathus* allied to *C. micropygus* and a *Euloma.* Several minute pteropods occur in these shales with the graptolites.

The fossils of this horizon are known only from one locality, near the Suspension Bridge at the "falls" of the St. John river, where they have escaped denudation owing to the complete overturn which the St. John group has undergone at that point.

Mr. J. F. Whiteaves then presented a paper on *The Fossils of the Hudson River Formation in Manitoba.*

The occurrence at the mouth of the Little Saskatchewan of rocks, which, on the evidence of a single fossil, were doubtfully referred to the Hudson River formation, is recorded by Dr. R. Bell in the Report of Progress of the Geological Survey for 1874-75. The first definite recognition of that formation in Manitoba, however, is contained in the Report of Progress of the survey for 1878-79, on the evidence of a large series of characteristic Hudson River fossils collected at Stony mountain by Dr. Ells in 1875 and by Dr. Bell in 1879, preliminary lists of which were given. An additional collection of fossils from this very prolific locality was made by Mr. Weston in 1884. In 1891 and 1892 Mr. D. B. Dowling found that Hudson River rocks occur also at Clarke's Harbour, ten miles north of the Little Saskatchewan, and at an exposure six miles north of Clarke's Harbour, at each of which localities a small series of fossils was obtained.

The object of the paper was to give as complete a list as possible of the fossils of this formation in Manitoba. In the museum of the survey there are now as many as sixty species from Stony mountain alone.

PROF. CHAPMAN contributed a paper *On Paleozoic Corals.* An attempt to simplify the determination of genera in the so-called Tabulated and Rugose corals of Paleozoic rocks.

SIR WILLIAM DAWSON then summarized in a very interesting manner his paper *On the Correlation of Early Cretaceous Floras in Canada and the United States, and on some new plants of this period.*

The purpose of this paper was to illustrate the present state of our knowledge respecting the flora of Canada in the early Cretaceous, and to notice some new plants from Anthracite, N. W. T., collected by Dr. Ami, and from Canmore, collected by Dr. Hayden. It was a continuation of the author's paper on the Mesozoic Floras of the Rocky Mountain region of Canada in the Transactions of the Royal Society of Canada for 1885.

Sir William Dawson then introduced a paper by Dr. Ami, of the Canadian Geological Survey, "On the Occurrence of Graptolites and other Fossils of Quebec age in the Black Slates of Little Metis, Quebec." This paper contains notes and descriptions of Graptolites and other fossils from an interesting collection made by Sir William Dawson from rocks which have generally been assigned to the age of the Quebec group.

PROF. L. W. BAILEY, of Frederickton, New Brunswick, in a paper entitled *Observations on the Geology of Southwestern Nova Scotia*, gives a review of the geological structure of Shelburne and Yarmouth counties, Nova Scotia, in the light of recent explorations made by the author, with a sketch map of the formations.

Section IV elected the following officers for the ensuing year:

President—J. F. WHITEAVES, F. G. S.
Vice-president—PROF. J. MACOUN.
Secretary—PROF. D. P. PENHALLOW.

The whole society elected the following officers:

President—J. G. BOURINOT, LL. D., etc.
Vice-president—GEORGE M. DAWSON, C. M. G., etc.
Secretary—J. FLETCHER, F. L. S.
Treasurer—A. R. C. SELWYN, C. M. G., etc.

Before adjourning the society extended a unanimous invitation to the Geological Society of America to hold their next winter meeting in Ottawa, Canada.

DR. GEORGE M. DAWSON, of the Geological Survey of Canada, has just had the honor of C. M. G. conferred on him by her Britannic Majesty.

THE

AMERICAN GEOLOGIST

VOL. X. AUGUST, 1892. No. 2

AN APPROXIMATE INTERGLACIAL CHRONOMETER.

N. H. WINCHELL, Minneapolis.

PLATES IV, V AND VI.

In the present stage of the rapidly unfolding geology of the glacial and succeeding epochs every opportunity to cast light on that interesting drama should be improved. The writer contributes the following discussion to the subject with a hope that it may have some weight in determining one of the questions which yet remain unsettled.* The evidence here given that a considerable interval of time, at least equalling that which has elapsed since the final withdrawal of the ice from the vicinity of the falls of St. Anthony, intervened between the first and second glacial epochs, is, perhaps, not conclusive proof, but in the opinion of the writer, it is far stronger than any evidence that has been adduced tending to reduce that interval to a mere recession and re-

*A previous paper by the writer, *The Geology of Hennepin County*, 1892, a chapter in *The History of Minneapolis*, I Atwater, contains the outlines of this discussion.

The duration of interglacial time has also been indicated by Pres. T. C. Chamberlin: *Some additional evidences bearing on the interval between the glacial epochs.* Bul. Geol. Soc. Am, vol. I, p. 469, 1890. The erosion of the trenches to which he alludes, at least so far as they lie within the drifted latitudes, seems to but very doubtfully indicate the duration of interglacial time, since, as urged by James Geikie (On the glacial period and the earth movement hypothesis, pp. 18-19) such valleys may have been eroded in periods long anterior to the first glacial epoch, or even in pre-Cretaceous times.

advance of the same glacial sheet, requiring a hundred, or two or three hundred, years; and as such if it should be accepted finally it will remove from the field of future controversy one of the extreme views of the shortness of that interval, and will open up a more clear, because more restricted, field for further investigation.

In the sixth annual report (1877) of the Minnesota survey (p. 70) allusion was made to an old gorge in Ramsey county, in the following words:

> There is some appearance of the former extension of the valley of Rice creek much further southward, and it is no unreasonable suggestion that the great Mississippi itself may have once occupied this valley, entering the great gorge again where it becomes remarkably widened, at St. Paul; but the evidence is entirely topographical. Such as it is it is perhaps overbalanced by a confusion of hills and high drift ridges north of St. Paul, which render it improbable that the Trenton is anywhere entirely cut through from the Rice creek valley to St. Paul, as would have been the case if the Mississippi ever passed through there.

Also, on p. 85 of the same report is the following statement:

> There is also a significant change in the direction [of the Mississippi], and one the more significant as it seems not to have been due to any rock formation existing at St. Paul, but directly contrary to the rock sculpturing that exists there favorable to the continuance of the river in any pre-occupied valley running in the same direction. Allusion has been made to a possible ancient gorge through the Trenton north of St. Paul in describing the surface features of the county, but on the geological map of the county no such gorge is represented, because it never has actually been discovered, and its hypothetical location would perhaps be of no service. * * * *
>
> These anomalous and significant facts can all be reasonably explained on the supposition that the Mississippi river was diverted from its ancient valley-gorge, north of St. Paul, by the ice and drift of the first glacial epoch, and that it was driven into that which has been described in the report on Hennepin county, toward the west further, and joined the Minnesota valley at some point above Fort Snelling, but between that point and Shakopee, without passing over or through the Trenton limestone at all. Their united waters then formed the river which excavated the gorge between Fort Snelling and St. Paul (unless the Minnesota alone had already done it) between the first and second glacial epochs.

Since that report was written several results have been attained which diminish the obstacles to the hypothesis which then existed. The extent and distribution of the moraines of the state have been established by more field work. The ancient discharge of the

Minnesota river eastward through some valleys which lead to the Mississippi river at points south of St. Paul, thus possibly removing the Minnesota river from the elements of the problem, has been described both by Mr. Upham and by the writer in reports on Martin, Blue Earth, Rice, Goodhue and Dakota counties. Some data from deep wells and from topographic levels have been obtained bearing upon the probability of a continuous old rock-cut valley extending from the mouth of Rice creek, near Fridley, to St. Paul.

More recently the attention of the writer has been given again to this subject,* and he has attempted to illustrate on plates IV and V and VI some of the data on which the conclusions of this paper are based. That the valley of the upper Mississippi is very old is evident on a moment's reflection.† That the main artery of its drainage must always have had a channel, more or less wrought in the rocky crust, is equally evident. It is also very plain that that old valley, and that old excavated channel, must have dated from the uprising of the rocks that formed the surface in the vicinity, from below the ocean's level. Many changes, perhaps such as to cause the shifting of the actual line of erosion by such drainage from place to place, within certain limits, may have taken place since the Archean rocks of the central region of Minnesota first began to shed the continental waters. Some of these may have occurred since the Cambrian and Lower Silurian rocks, which are the only ones (with one non-important exception) which now exist in the region concerned later than the Archean, rose above the ocean and added their quota to the land area of the region. Allowing for all these shiftings, which are entirely hypothetical and have no claim to be allowed, in any exact statement, yet it will be at once admitted that there was sufficient of quiet in the interval from the Lower Silurian to the present, to permit the early Mississippi to excavate what might be styled a "base-leveled" gorge through the rocks over which it flowed. We will not here enter upon the evidences that the present gorge is the oldest, dating from Silurian times, at least between St. Paul and the southern boundary of the state, but will simply call attention to the fact that the immediate source and the mouth are most

**Op. cit.* The Geology of Hennepin County.

†E. W. CLAYPOLE. The Story of the Mississippi-Missouri. AMER. GEOLOGIST. Vol. III., pp. 361–377.

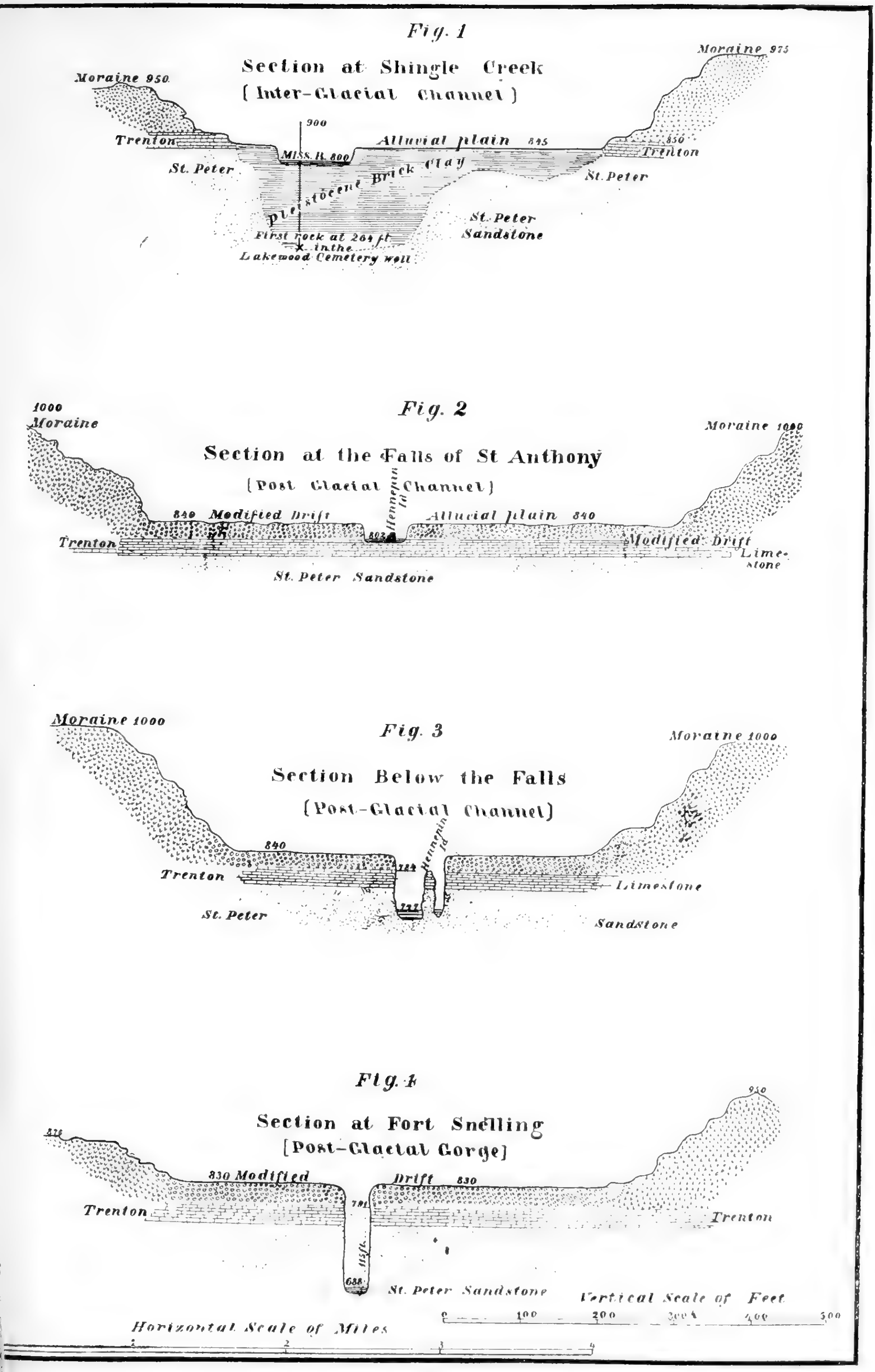
subject to change, the former by recurring glaciation, and the latter by oscillation of the coastal lands. It is therefore obviously a *non-sequitur* to base any statements respecting the age of the upper Mississippi on facts and features that may be observed in the lower portion of the valley, and this will apply, with proper limitations, to a great many of the tributaries of the Mississippi.

Such "base-leveled" channel, with steady slope and easy current, could have had no water-falls such as are produced by alternations in the rock-strata with which streams come in contact in drift-covered latitudes. The occurrence of a water-fall in a river implies a comparatively recent change in the location of its bed. The same is true of rocky rapids. The drifted regions abound in water-falls. The non-drifted are without them; but *vice-versa* the drifted regions are scantily supplied with deep river-cut gorges, and the non-drifted are scored by deep gorges cut by the surface drainage.

Such a valley is the gorge of the Mississippi, from St. Paul to the Iowa state line. Its depth is not measured by the hight of the present bluffs, for the excavation is found to extend several hundred feet below the present surface of the river. It has recently been partly refilled. Drift deposits (gravel and sand) lie upon the bottom of the rock-gorge and have a thickness of over two hundred feet.

As the eroded valley is immensely deeper, within Minnesota, than the present bluffs, so it is also wider. The Trenton limestone which was its bed in Upper Silurian time and perhaps in Carboniferous, now forms bluffs along each side some miles distant, having been wasted away more rapidly than the other, lower, limestone strata, through the disintegrating action of the erosible St. Peter sandstone immediately underlying it. (See plate v, fig. 3). These distant Trenton-St. Peter bluffs approach the river toward the north further, and at the falls of St. Anthony the Trenton again forms the bed of the river, being the barrier at the brink over which the water plunges. (See plate iv, fig. 2.)

The study of the falls and the surrounding region has revealed some earlier history of the river, and has brought to light some of the abandoned gorges which the river formed in interglacial and pre-glacial times. The oldest valley seems to have been the most direct one, viz: that extending from the mouth of Rice creek above Minneapolis, to the mouth of Trout creek, at St. Paul.



SECTIONS ACROSS THE MISSISSIPPI RIVER.

This is also the most frayed and smoothed off with age and surface disintegration, thus becoming wider and less distinct.

In 1680, when father Hennepin, the discoverer of the falls of St. Anthony, taken by the Sioux Indians in the vicinity of La Crosse, was led in captivity to lake Mille Lacs, the source of the (then) St. Francois river, they left the Mississippi at St. Paul and apparently followed this route to avoid the rapids and falls of St. Anthony; for in this valley are several lakes and from them flows a canoeable stream to the Mississippi again, northward.

There is a significant break-down and total lack of the Trenton limestone at St. Paul on the left bank, just above Dayton's bluff, for a distance of nearly a mile. This break-down occurs on one side of the right angle which the river there makes, and directly where the course of the present river-channel below, if extended northwestward without the right-angled turn, would encounter the bluff. This fact alone is significant of changes in the course of the gorge of the Mississippi as occupied and eroded at different epochs in the past. On following up this intimation, the inquiring geologist ascertains that there is not only no known existence nor any sign of the Trenton limestone anywhere northwestwardly, and that the St. Peter sandstone a lower stratum occurs in outcrop in the low grounds intervening between the mouth of Trout brook and the mouth of Rice creek, but also that on either side, at a short distance, the Trenton still exists. On the southwest side it rises into a conspicuously hilly tract, and includes some of the highest beds belonging to this formation known in this part of the state. On the northeastern side it is less prominent, occurring so far as known, mostly as remnants of the outrunning fringe of the formation. But still further east, across a wider valley, a conspicuous spur of the higher beds of the Trenton shoots off northeastwardly, diverging from St. Paul and passing into Washington county at Castle. This shows that at some former time there was a great valley northward from St. Paul, whose east and west sides diverged from the break-down in the Trenton which has been mentioned. One portion of this great valley, lower now than the rest, extends northwestwardly to the mouth of Rice's creek and there encounters the present Mississippi river six miles above the falls of St. Anthony. In this portion of this valley lie McCarron, Bennett, Josephine, Johannah and Long lakes, connected with the Mississippi, either toward the north or toward the south and with each other, by Rice creek and Trout brook, constituting a marked valley which connects the Mississippi above the falls with the Mississippi below the falls by a nearly direct course. (Compare plate VI.)

The writer, in former papers, has discussed the recession of the falls of St. Anthony,* and has deduced a time-measure for their recession from Fort Snelling to Minneapolis, and has shown that this also measures the time elapsed since the last glacial epoch. This result, approximately 7,800 years, has generally been accepted by glacialists, especially in America. It was shown that just prior to the last general glaciation the Mississippi river at Minneapolis occupied an old valley which diverges from the present channel within the limits of the city, at the mouth of Bassett's creek, passed southward where now a series of lakes lie (Calhoun, Harriet, etc.) and joined the present Minnesota channel at some point a short distance above Fort Snelling. There it turned to the northeast, at a right angle, and went on to St. Paul, and thence, with another right angle, as now, it finally took its undeviating course southward. The significance of the first of these right angles has been pointed out in that earlier discussion. It is the purpose of this paper to point out and discuss the significance of the second.

In the light of what has been shown for the first it is a reasonable expectation to find a similar explanation of the second, should similar or identical conditions attend the second.

Those conditions are:

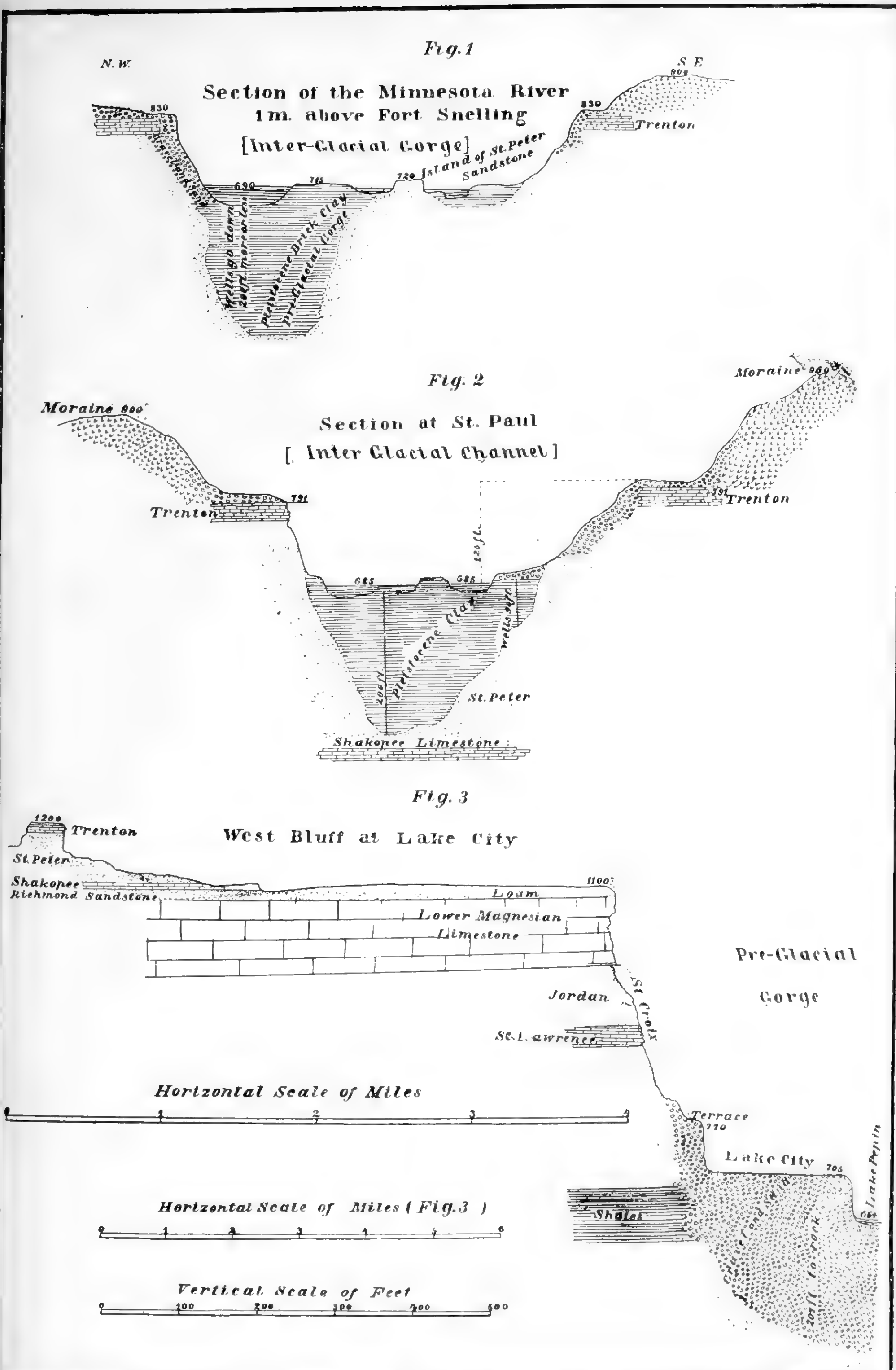
1. A great river seeking a channel of discharge, through a country uniform in its topography and geological structure, to the ocean.

2. The derangement of the natural, direct and primary course of its erosion by the on coming of the conditions of a glacial epoch.

3. The choking up of the (then) existing channel and the acceptance by the river on the retirement of the glacial conditions of another slightly different channel.

4. Its entering again upon its old channel at a lower point, and the birth at that point of a new waterfall.

*Fifth annual report of the Geological Survey of Minnesota, 1876, pp. 156-189. Quart. Jour. Geol. Soc. Lond., Nov., 1878, pp. 885-902. Final report of the Geological and Natural History Survey of Minnesota, vol. II, pp. 313-341.



SECTIONS ACROSS THE MISSISSIPPI RIVER.

5. The recession of this waterfall backward till it cut a gorge through the obstruction which it had been compelled to surmount rather than flow round.

6. The greater depth, width and different direction of the old gorge from the gorge which the river excavated in the later stage of its history.

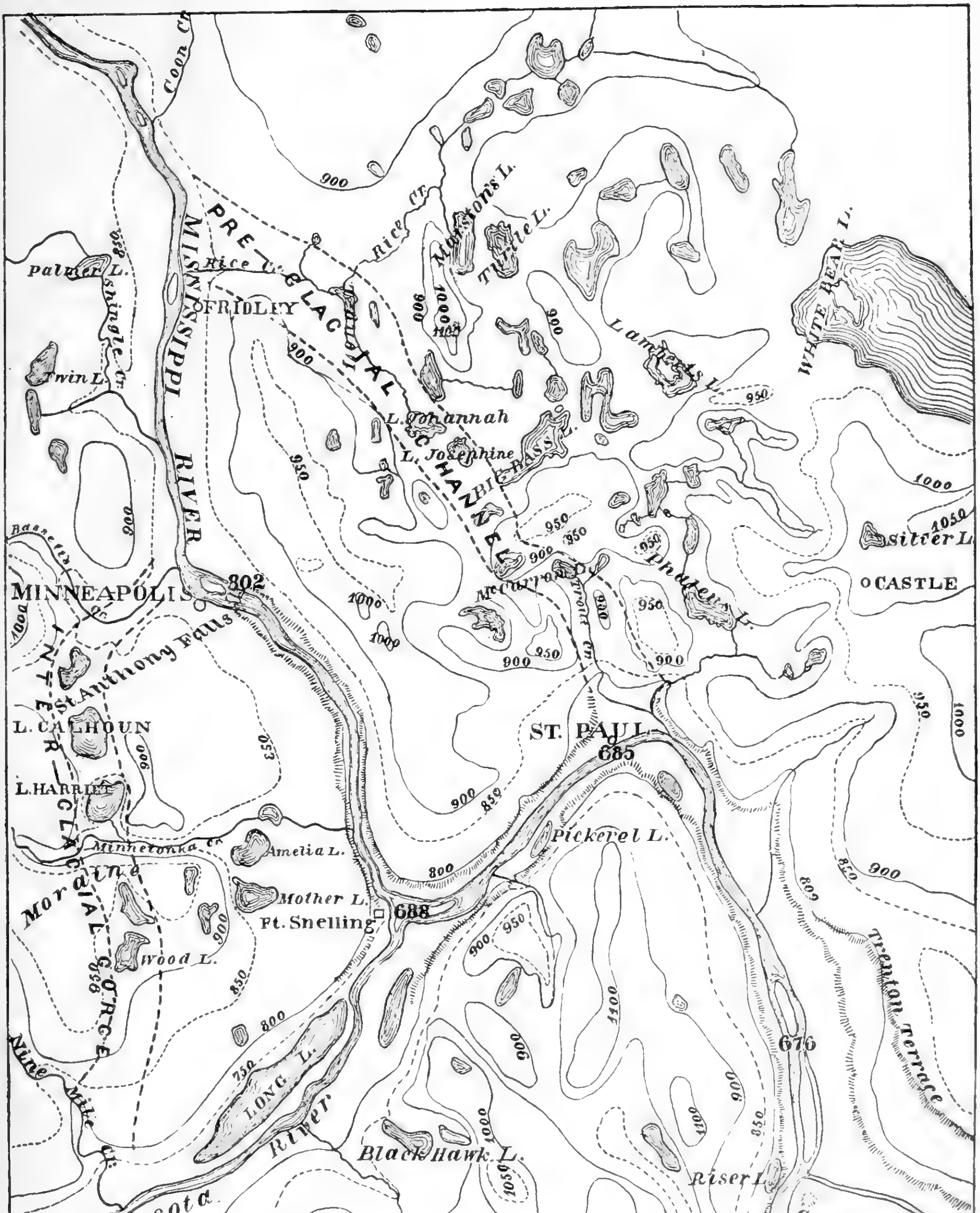
7. The existence of another older valley from which the river might be presumed to have been expelled.

8. The movement of the ice, in general, in that direction, about the falls of St. Anthony, which would tend to throw the river from its supposed older channel toward its supposed newer.

These conditions all do exist, in connection with the second right angle, as plainly as they do in connection with the first. The map on the accompanying plate (VI) illustrates them. The difficulty which we encounter in attempting to handle the facts consists in the consciousness that they relate to a very old history. We have not often attempted to place time limits on geological data, and when we have ventured to do it we have confined our assays within post-glacial time. Our next step must be beyond the border that sets off post-glacial history as a unit of geological time amenable to our scrutiny, and leads into interglacial time. We reach the results inductively, just as we have for post-glacial time. Here are a set of facts. They need reasonable interpretation. That hypothesis which suited the other set of identical facts is naturally the first one invoked for this. Does it apply as well?

The movement of the ice of the first glacial epoch has been stated to have been from the northeast in the vicinity of the falls of St. Anthony, that of the second from the northwest. This is based on the prevalent direction of transport shown by the nature of the drift materials when they are referred to their native places. The lower till—the copper-colored or red till—has a preponderance of rock debris from the region of lake Superior, and northern Wisconsin. The upper or gray till, which has a marked contrast with the red, has a preponderance of rock debris from the direction of the Red river valley. These tills come into contact about Minneapolis and St. Paul, and in all places where the two are seen in place, the gray overlies the red, but they are frequently separated by a layer of sand and gravel referable to the epoch of the red. When the glacier which deposited the red drift approached the region of Minneapolis it must have found the Mississippi running in its most direct course southward, for it can only be supposed that the ordinary events of ordinary seasonal changes, and ordinary erosion of the surface of the country, prior to that event, would have acted to determine the location of the stream. Archæan highlands existed toward the east, in Wisconsin, and toward the west, in Minnesota. When the land rose from the Cretaceous baptism, those highlands must have shed their surface waters toward this valley. The resultant main stream, taking the easiest course toward the sea, excavated its channel first through the Cretaceous sediments and then into the Silurian or other strata, guided only by the accident of posé of the surface. If we know of no cause that could have diverted it, as we do not, we must suppose, *a priori*, that its course would be the most direct and shortest to reach sea level. We take no account here of the possible, and even probable, existence of a pre-Cretaceous river and hence a pre-Cretaceous gorge, for had such existed it would, in the first instance, have been governed in its location by the same influences. We might add, that had such pre-Cretaceous gorge existed, its effect on the contours of the surface after the mantle of the Cretaceous sediments had been spread over the region, would have been favorable to the re-location of the stream, when the land became dry again, in the same gorge as it had excavated in pre-Cretaceous time, and hence that it matters but little whether we discuss here the pre-Cretaceous or the post-Cretaceous drainage. In either case the shortest, and the lowest line of drainage was chosen. A glance at the map, and a knowledge of the geology of the region would at once indicate that the Mississippi, on the advent of the first glacial epoch, was probably running in the valley which has been referred to, from the mouth of Rice creek to the mouth of Trout creek, thus cutting out both of the right-angled turns that it now makes between those points. This valley it must have occupied during Tertiary time at least, and probably since Lower Silurian time.

Where was the Mississippi running on the withdrawal of the ice of the first glacial epoch? As has been stated, it was shown that when the second glacial epoch approached, the Mississippi was running in a channel excavated through the Trenton-St. Peter along the western suburbs of Minneapolis and reached the Minnesota valley at some point above Fort Snelling, and it is fair to as-



CONTOUR MAP OF THE VICINITY OF THE FALLS OF ST. ANTHONY.

sume that it was driven there by the events and forces of the first glacial epoch, and that it had occupied it during the time that intervened between the two glacial epochs. But that is an excavated river gorge, cut in rock in a manner similar to the present gorge, except that it is wider. Our problem is to measure the time required for such excavation, for we are obliged to infer that the manner of its excavation was by the *recession of an interglacial falls of St. Anthony.*

In this problem there are some elements identical with those which were employed in the calculation of the time required for the formation of the post-glacial gorge, and there are some which are somewhat different.

Those which are the same are:

1. The general slope of the country.

2. The contact of the two formations which conspire to cause the water-fall.

3. Uniform and horizontal position of the same rocks.

4. Definite limit for the upper end of the eroded gorge.

The elements which are different, or uncertain, are the following:

1. The size of the river.

2. The lower end of the excavated gorge, *i. e.* whether the falls began at that point above Fort Snelling where the Mississippi at that time met with the Minnesota river, or at a point at St. Paul opposite Dayton's bluff, where the lower right-angled turn takes place.

As to the size of the river during interglacial time we have no definite data, except that we may infer that it was not so large but that it could flow in the gorge it excavated. We have no reliable data by which to estimate the annual precipitation over the region which the river must have drained. It was a period in which some of the mountain ranges of the western country did not exist. The Rocky mountains did not extract and return to the Pacific ocean the moisture from the western winds quite so readily as they do now, and hence the contrast in annual rainfall between the plains and the eastern portions of North America was not so marked. Again there must have been active volcanoes in the western portion of the United States and perhaps some in Colorado. These must have disturbed the atmospheric conditions, causing at least in their near vicinity, copious rains, and these centers of atmospheric disturbance were doubtless in some instances wafted far eastward, and even northward, shedding on the plains more moisture than they receive now. The present size of the interglacial gorge being somewhat larger than the post-glacial gorge, even after making allowances for some enlargement by the disintegrating action of the last glacial epoch, and there being some reason to think the western country was wet in many places where now it is dry,* it is reasonable to infer that the river was permanently sustained at a higher stage by a greater precipitation. If this be allowed we shall have to admit that it would act more powerfully at the brink of a receding waterfall, and that the recession of such water-fall, for any given length of time, all other things being equal, would have been more rapid in interglacial time than it has been in post-glacial time. This difference may have amounted to twenty-five per centum of the post-glacial recession.

In regard to the point of debouchure of the interglacial Mississippi into a pre-existing gorge, giving rise to a water-fall at the commencement of interglacial time, there are such uncertainties that it will not be possible to determine whether it was at St. Paul, opposite Dayton's bluff, or at a point in the Minnesota valley a few miles above Fort Snelling. This all depends on how old that portion of the Minnesota (now the Mississippi) valley is, between St. Paul and the supposed point of junction above Fort Snelling. There is some reason to suppose that the Minnesota river did not always unite with the Mississippi where it does now, nor at any point in the vicinity. The Minnesota itself, at Mankato, has a significant right-angled elbow, and at other points further north it shows signs, especially in glacial and post-glacial time, of having taken a course to the Mississippi across Rice, Dakota and Goodhue counties. At earlier dates its waters may have found passage to the sea toward the southwest and the Missouri river, or through some of those deep rock-cut gorges which characterize the Undine region in Blue Earth county, thus having had some agency in the pre-glacial sculpturing of those cáñons in which lie the curious "chains of lakes" which Mr. Upham has described in Faribault county.

*This difference is indicated by the existence of interglacial peat beds in southern Minnesota, and the discovery of many trees like cedars whose habitat is usually in swamps, in the upper till as well as in the peat beds.

Be all that as it may, there is one fact which tends rather in the opposite direction, and indicates that the Minnesota itself cut a gorge between St. Paul and Fort Snelling and also further up its valley even in pre-glacial time, and that the interglacial Mississippi found this gorge in existence when it was compelled to abandon permanently its own pre-glacial gorge. That evidence consists in the depth of the gorge between St. Paul and Fort Snelling. This excavation has to be measured through the whole thickness of rock-strata which have been cut, regardless of the accidents of the present, for the spreading of the drift has obscured the history of the river preceding the ice age. This country became dry land, so far as can be judged from the latest marine formations (not considering the Cretaceous), at the close of the Lower Silurian. The whole of the Lower Silurian was probably deposited throughout the area included in this calculation, and at the present time there are preserved, in the hills to the south of St. Paul, as well as at St. Paul and toward the northwest and northeast, as already stated, some of the higher layers of the Trenton, even including some distinctively Galena characters. The thickness of all the Trenton beds (shales and thin limestones) is 114 feet. The St. Peter is exposed, above the river level, about 75 feet, and the gorge, as revealed by deep wells, is cut about 200 feet below the water level. The total excavation in the rock therefore is 389 feet. As this comports with the general depth of the Mississippi gorge below St. Paul, which must be referred to pre-glacial history, rather than with any excavation that can be referred to interglacial time, it points strongly to pre-glacial time for the excavation of the valley between St. Paul and Fort Snelling—and hence also to the occupancy of the present valley in general by the Minnesota since pre-glacial time.

At any rate, whether the interglacial falls began at St. Paul or not, the length of time required for their recession to the mouth of Bassett's creek is sufficiently long for the purpose of this paper. We will, therefore, assume the shorter recession, and calculate from the point above Fort Snelling on the Minnesota bluffs at which the Mississippi may be supposed to have leaped from the Trenton limestone to the river below when it was driven from its pre-glacial gorge.

In a direct line the mouth of Nine-Mile creek in Bloomington township, which may most reasonably be taken as the point of commencement of the interglacial falls of St. Anthony, is distant from the mouth of Bassett's creek where they stopped their recession, twelve and a half miles, or about 50 per cent. further than the distance through which the post-glacial falls have receded, from Fort Snelling to Minneapolis. Taking the results of the calculation of the post-glacial recession as a measure of interglacial recession, we find they compare with the interglacial conditions as follows:

Post-glacial recession 8½ miles, in 7,800 years.

Interglacial recession, 12½ miles, at a rate perhaps 25 per cent. faster.

The greater distance will more than compensate for the greater rate, and will allow us to add to the time required about 25 per cent. of the post-glacial time. This indicates 9,750 years for the lapse of time required for interglacial recession.

Such an interval of time, if it occurred between the two glacial epochs, would allow for something more than the temporary retreat and re-advance of the same ice sheet. It would give time for the weathering of the till of the first glacial epoch and the excavation of valleys in it by interglacial streams. It is time sufficient for the growth of forests and the accumulation of peats, for the development of a somewhat characteristic fauna and flora, and for the establishment of some human habitation as well as civilization. The whole Egyptian dynasty, and perhaps the dawn of the Chinese, might be compassed in such a period.

NOTES ON MANGANESE IN CANADA.

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(Communicated by permission of the Director.)

In preparing the following brief sketch of the various important deposits of manganese in Canada, I have embodied the greater part of the article on that substance which I prepared for the annual report of the division of Mineral Statistics and Mines for 1890.*

That the industry has not attained greater commercial prominence is due rather to its distance from market than to any insufficiency of supply; this applies, however, more especially to

*Annual Report Geol. Surv., part S, Vol. v, 1889-90.

the low grade or blast furnace ores than to the highly crystalline pyrolusite for which the market is restricted. Of the geographical position of the ore deposits little need be said beyond the fact that the worked and, as far as is yet known, the workable deposits are all situated within New Brunswick and Nova Scotia. Throughout these provinces are found many comparatively extensive deposits of the crystalline and semi-crystalline ores, viz: pyrolusite, manganite and psilomelane, as well as large areas of wad or bog—manganese. The crystalline ores are, in the majority of cases, found in rocks of Lower Carboniferous age, while the bog ore deposits, being of recent formation, are found overlying rocks of any formation from the pre-Cambrian upwards.

New Brunswick.—In New Brunswick the most important deposit of the crystalline ores is that at Markhamville, Sussex, Kings Co., from the workings of which upwards of 20,000 tons have been shipped. The ore deposits are irregular beds, pockets and veins in a small area of Carboniferous limestone, on the northwest side of which are located the workings. Many of these ore bodies have attained large dimensions, one of them affording in the neighborhood of 4,000 tons of manganite with a considerable proportion of pyrolusite. The discovery of manganese at this point was made in 1862, when it was worked by Mr. Wm. Davidson, of St. John, until 1865, after which the property passed into the hands of the Queen Manganese Co., by whom it was operated under the management of Major A. Markham until 1889, when it again changed hands and was operated, still under Major Markham, by the Pope Manganese Co. Owing to the location of the deposits, in a valley cut through the softer limestones, no regular system of mining has been attempted, the operations being, until quite recently, altogether in the form of drifts and open cuts with which the hill on the north and west side of the property is literally honey-combed. During 1890, however, explorations were being made by means of the diamond drill, with the result that two deep-seated deposits had been found and were being sunk upon.

Of the ore shipped from this mine two distinct classes are recognized, viz: "Blast furnace ore," consisting almost entirely of manganite, and high grade or "grey ore," consisting of pyrolusite. The following analyses are of "high class manganese ore from Markhamville, New Brunswick" and are taken from "The

Mineral Resources of the United States, calendar year 1888." Washington, 1890:

	No. 1.	No. 2.	No. 3.
Manganese binoxide	98.70		
" peroxide		97.25	96 62
Silica	0.55		
Iron	0.75		
Iron peroxide		0.85	0.78
Barium	trace		
Baryta and silica		0.95	0.85
Water		trace	trace
Loss		0 95	1.75

Another important deposit of crystalline ore is that of Jordan mountain about five miles north of Sussex, Kings Co., and on the western side of the mountain. The ore bodies occur in a manganiferous limestone throughout which are scattered, in a manner similar to that at Markhamville, more or less extensive deposits of pyrolusite and manganite. Since its discovery in 1882, by the present owner, Mr. F. W. Stockton, of Sussex, but little has been done, further than a small amount of development work, consisting of stripping and an open cut of about eighty feet in length, in the bottom of which might be seen an interbedded lenticular mass of ore, principally manganite. From this cutting about 400 tons of eighty to eighty-five per cent. ore had been extracted.

Operations have been carried on for many years and by different companies at Quaco Head, a bold rocky promontory about one mile southwest of the village of St. Martins, Kings Co., unfortunately, however, with but slight success, owing to the low percentage of ore contained in the rock mass. The deposit consists of a heavy bed of red calcareous shale highly charged with manganite and psilomelane, pyrolusite being of much rarer occurrence than in the limestone deposits of the aforementioned localities. The property has been worked in a very desultory manner for many years, energetic operations not having been undertaken until its acquisition by the present company, who began work by driving a tunnel into the shales which show a bluff face of about 150 feet high. From this tunnel, which was driven about sixty feet, two cross-cuts were made in either direction for about twenty feet. In these workings several small pockets and considerable quantities of mill-rock were struck and the ore extracted, though no shipments were made. In connection with the mine a well equipped mill was erected and a wharf built and all facilities made for the easy handling of the ore. Owing to the position of the mine, ore could be run direct from the workings to the wharf and loading accomplished at one handling by means of self-dumping cars.

Assays of the concentrated ore made by A. M. Cowly, Cambridge, Mass., gave the following result:

	Compact variety.	Porous variety.
Manganese dioxide	71.54	65.00
Insoluble silicates	8.37	6.66
Ferric oxide	2.19	1.75
Ph· sphorus	0.02	0.04
Calcium	trace	trace
Metallic manganese	58.20	57.15

A considerable proportion of lime is generally present in the concentrates, which will not, however, interfere with their fitness for use in the manufacture of steel for which purpose all the ore from this property will be most suitable.

A peculiar occurrence of manganese is that which is to be seen on the north and northeast side of Gowland mountain, Elgin, Kings Co., where the ore, consisting principally of psilomelane, is found filling the interstices of a very much broken and partly decomposed granite of pre-Cambrian age. A small amount of development work was done on these deposits without, however, locating any other than small bunches of a very impure pyrolusite and psilomelane. The following analysis made in 1885 by Mr. F. D. Adams, late assistant chemist to the Geological Survey, is that of a specimen of psilomelane from this property:

Manganese dioxide, available	50.21	per cent.
Ferric oxide	3.06	"
Insoluble residue	33.78	"

The specimen also contained a very appreciable percentage of baryta.

This property is peculiar in affording the only instance in New Brunswick where the crystalline ores of manganese are known to occur in appreciable quantity outside of the Carboniferous areas.

Other localities where manganese, in its crystalline forms, have been noted are, Upham, Waterford, near Petitcodiac, Springfield, Tête-à-Gauche Falls, and many points throughout Albert county. Of one of these, Shepody mountain, Dr. R. W. Ells, in his report to the Geological Survey for 1884, writes: "The rocks of the mountain (Shepody mountain) rest upon a small outlier of the talco-chloritic schists. which show on the road to the north, leading to Curryville, and are flanked on the east by the grey sandstones of the millstone-grit. On the northwest side a large deposit of manganese was worked for some years, a tunnel being driven into the mountain along the contact with the underlying schists for nearly 1,000 feet, the ore, which consisted of pyrolusite and psilomelane, occurring at the base of the conglomerate in irregular pockets. Operations have been suspended for some years, and the workings have all fallen in."

Of the deposits of wad in New Brunswick the most important are those at Dawson Settlement, Albert Co., where many acres of ore are found, the beds varying in extent and depth, and attaining in some places a thickness of over forty feet, to which point they have been proved. The deposits are covered throughout with peat and peaty matter, having a thickness of about twelve to twenty inches, the ore beneath this being found to be practically free from impurities. The mode of working is very simple, consisting of cross trenching, by which means the deposits are drained, after this the ore is excavated and dried in pans, the result being a dry and almost impalpable powder.

A partial analysis of the ore by Mr. W. F. Best, of St. John, gave:

Manganese binoxide	47.0
Iron oxide	18.0
Vegetable matter	34.0
Loss	1.0
Copper	trace
Cobalt	trace
	100.0

Several analyses by Mr. John Burwash gave the following percentages of manganese binoxide: 73.6, 35.5, 58.3, 57.6, 70.7, 63.4, and an average specimen collected at various points and sampled gave 47.4.

Nova Scotia.—As in New Brunswick extensive deposits of manganese are known to exist in Nova Scotia, where the ores and mode of occurrence are similar though differing in a great measure in the matter of production, that of this province being much smaller than that of New Brunswick. In Nova Scotia, however, there is a very large proportion of pyrolusite or high grade ore.

On the south shore of Minas Basin and midway between Noel and Walton, is situated the best known and most important manganese mine in Nova Scotia, the Teny Cape mine, which, since its discovery in 1862, has been operated more or less continuously. The ores, consisting mainly of pyrolusite and manganite, are found in the Carboniferous limestone which may be traced for many miles on the south shore of Minas Basin, the limestone immediately in connection with the ore deposits being highly manganiferous and interstratified with small beds and masses of manganiferous calc-shale, the whole being usually of a deep red color. The mode of occurrence is pockety, the ore being found in irregular masses and stringers which follow the bedding planes and fractures; some of these pockets are of considerable extent, one affording, it is said, upwards of 1,000 tons of high grade ore, principally pyrolusite. A very considerable proportion of all the ore extracted from this mine has been pyrolusite worth from $100 to $125 per ton at the works, and containing from 85 to 95 per cent. of available binoxide.

The following assays taken from an article entitled "Notes on the Manganese ores of Nova Scotia," by E. Gilpin, Jr., show the character of the ores obtained from Teny Cape and vicinity:

	Teny Cape (*a*)	Cheverie (*b*)	Douglas
Manganese oxides	85.54	90.15	84.62
Iron peroxide	1.18	2.55	0.60
Baryta	0.89	1.12	0.72
Insoluble matter	3.27	2.80	1.73
Phosphoric acid	0.34	1.03	
Water	8.54	2.05	5.29
Oxygen			7.04
	99.76	99.70	100.00

(*a*) Analyst, Dr. Howe.
(*b*) " E. Gilpin, Jr.
(*c*) " H. Poole.

Deposits similar to that at Teny Cape have been worked to a smaller extent at Cheverie, Walton, Noel and Shubenacadie, on the south shore of Minas Basin, while on the north shore no important deposits of manganese have been noted, though some of the limonite and other iron ores of the neighborhood of Londonderry are highly manganiferous; this is also the case with many of the iron ores of both Colchester and Pictou counties.

The following assays, taken also from Mr. Gilpin's article mentioned above, show the character of some of these ores, the particular cases cited here being of two limonite ores from Springville, Pictou county.

Iron sesquioxide	10.848	48.223
Manganese oxide	62.950	
" peroxide		14.410
Magnesium	1.630	
Lime	7.280	0.015
Alumina	2.880	Trace
Baryta	0.670	
Sulphur		0.480
Phosphorus		0.020
Insoluble residue	2.731	25.130
Water of composition / Moisture	1.450	12.530
	90.439	100.808

On Cape Breton island as well as on the main land of the province are found deposits of manganese, some of which attain considerable dimensions. Among the more important of these may be mentioned those situated near Loch Lomond, and of which Mr. Hugh Fletcher reports as follows: Geological Survey report, 1882-84:

"Large deposits of pyrolusite, which promise to be of great importance, have recently been discovered and developed by the Hon. E. T. Moseley, of Sydney, on the south side and near the head of Loch Lomond, in Cape Breton county. The ore is associated with lower Carboniferous rocks and has been worked in two places about three-quarters of a mile apart. At the most easterly of these, in a brook on the farm of Norman Morrison, a tunnel has been driven about thirty feet on a vein about seven inches thick, dipping N. 87° W. $< 25°$ in fine red sandstone overlying reddish and greenish grit, with grains of quartz about the size of wheat and red marly sandstone. The ore is irregularly mixed with red and grey bituminous limestone, red and greenish shale conglomerate and other rocks blotched with calcspar. It is in lenticular layers and also intimately mixed with the limestone, being probably of the same nature and origin as the hematite and forming at times a cement for the pebbles of the conglomerate * * * The mines were first worked in 1880. In 1881 about 70 tons, and in the following year 59 tons of excellent ore were shipped to the United States, * * * An analysis of a sample from the Morrison mine afforded Mr. Adams 91.84 per cent. of manganese dioxide, only .12 per cent. of ferric oxide and 2.91 per cent. of insoluble residue."

Many other deposits, both of crystalline ores and wad, are known to exist throughout the island. One of these on Boularderie island is said to be quite extensive, and the character of the ore may he judged from the following assays:

	I.	II.	III.
Manganese per xide	25.42	11.04	44.33
Iron sesquioxide		12.49	35.50
Insoluble matter		57.76	10.00
Water	33.52		

I and II by G. C. Hoffmann, Chemist Geological Survey. III by E. Gilpin, Jr., Trans. Royal Society of Canada, Vol. II, sec. IV.

Ontario and Quebec.—Outside of Nova Scotia and New Brunswick but little manganese is known to occur, and where noted is usually of low grade. In Quebec several small deposits of wad have been noted, the largest, perhaps, being that in Stanshead township, where on lot nine, range ten, the ore covers an area of about twenty acres, and has a thickness of about twelve inches. That this deposit has but slight commercial value is evidenced by the fact that the washed ore contains only 37% of peroxide. Another deposit, similar to the above, occurs on lot twenty, range twelve of Bolton, the ore there assaying 26%. Many similar deposits might be mentioned, though probably none as important as those noticed above.

Manganese has also been noted as occurring on the Magdalen islands, a small group in the gulf of St. Lawrence. Of these deposits Mr. Jas. Richardson in the report of the Geological Survey 1879-80, writes: "Immediately under Demoiselle hill, on Amherst island, numerous blocks charged with peroxide of manganese, or pyrolusite, occur among the debris of the fallen cliffs. They are in pieces varying from one pound to ten or fifteen pounds in weight. There can be little doubt that they are derived from a deposit more or less regular in the hill side, but which is now completely concealed by the fallen debris. At a place bearing nearly due west from Cap aux Meules, at a distance of about a mile, and close to the English Mission church, similar pieces to those above described are very frequently picked up." Assays of this ore, in the same volume, gave:

Manganese dioxide	45.61 per cent.
Water, hygroscopic	0.10 "

In Ontario manganese has been reported from Batchewaherung bay, lake Superior. The ore is manganite and is said to assay as high as 60% of peroxide; of the extent and exact situation of the deposit it is not possible to write.

An interesting discovery of a manganiferous spothic iron ore is reported by Dr. R. Bell in the report of the Geological Survey 1877-78, wherein he states that a band of about twenty feet of the ore, carrying 25% metallic iron and 24% carbonate of manganese, occurs in the Nastapoka islands, a group off the east coast of Hudson bay. The ore is easily accessible and will no doubt eventually prove of value, the high percentage of manganese contained making it eminently suitable for the manufacture of speigeleisen.

KEOKUK GROUP OF THE MISSISSIPPI VALLEY.

CHARLES S. BEACHLER, Crawfordsville, Indiana.

LITERATURE.

The name *Archimedes limestone* was given by David Dale Owen, 1852, Geological Survey Wisconsin, Iowa and Minnesota, to the forty feet of the heavy bedded, quarry, encrinital limestone, quarried in the bluff at Keokuk, Iowa. This bed in his table of the sub Carboniferous rocks of the Mississippi valley is placed as the uppermost member of the lower sub-Carboniferous; he terms the preceding rocks the *Cherty limestone.* The Archimedes limestone bed is succeeded by the lowest two members of the upper sub-Carboniferous which he named (a′) *Geodife ous Bed*, and (b′) *Magnesian limestone.* From the great number of fossil shells found in the lower part of the Archimedes limestone he uses a special name, that of *Shell Beds*, to distinguish it.

These four beds form what has developed into the Keokuk group of the sub-Carboniferous period.

(Keokuk) 1852. OWEN.	Upper sub-Carboniferous	(b′) Magnesian limestone.
		(a′) Geodiferous Bed.
	Lower sub-Carboniferous	(f) Archimedes limestone.
		(e) Shell beds.
		(d) Cherty limestone.

S. C. Swallow, 1855, First and Second Annual Reports of the Geological Survey of Missouri, applies Owen's name Archimedes limestone to all the rocks from the summit of the Encrinital series to the base of the Saint Louis series; from the description on page 183 it seems that the Cherty bed was regarded as the summit of the Encrinital limestone series. No other divisions were made.

	Saint Louis limestone.	
(Keokuk) 1855. SWALLOW.	Archimedes limestone.	
	Encrinital limestone	Cherty beds.

James Hall, 1858, Geological Survey Iowa, volume I, in arranging the sub-Carboniferous rocks of Iowa, places the Cherty and Archimedes limestone as two distinct beds under the division *Keokuk limestone*, which term he uses instead of Owen's name Archimedes limestone, dropping the term Shell beds; the Geode bed is made a transition bed, and the Magnesian limestone is termed the *Warsaw limestone* and placed under that division.

	Warsaw limestone.
	GEODE BED.
(Keokuk) 1858. HALL.	Keokuk limestone.
	Cherty limestone.

A. H. Worthen, 1866, Geological Survey of Illinois, volume I, unites the whole section of Owen and Hall under the name KEOKUK GROUP, with the exception of the Magnesian or Warsaw limestone, which he seems to consider as a division of the Saint Louis, as seen by his referring the equivalents of the Iowa Magnesian limestone, in Indiana at Bloomington and Spurgeon Hill to the St. Louis group.

	WARSAW LIMESTONE.
Keokuk Group. WORTHEN. 1866.	Geode bed. Keokuk limestone proper. Cherty limestone.

Charles A. White, 1870, Geological Report of Iowa, volume I, uses Hall's names and divisions.

Synonym—SILICIOUS GROUP.

James M. Safford, 1869, Geology of Tennessee, proposes the name *Silicious Group* for rocks of the age of the "Highlands" of Middle Tennessee, and refers the

Upper Silicious to the *Warsaw and St. Louis.*
Lower Silicious to the *Keokuk.*

GEOLOGY.

The rocks of the Keokuk group occur in broad belts on both the eastern and western borders of the great Illinois coal field; in Indiana and Kentucky on the eastern border, extending into Tennessee and Alabama, and in Illinois and Iowa on the western border extending into Missouri.

On the western border in Illinois and Iowa, where typical localities are found, the rocks are exclusively of a calcareous character attaining a maximum thickness of at least two hundred feet; in Missouri the uppermost member of the group, the Magnesian limestone, forms the principal representative and has undergone great local disturbances in the central part of the state. On the eastern border in Indiana and Kentucky the rocks occur as alternating beds of argillaceous sandstone, limestone and shale, thinning out toward the east and pass downwards into the Knob-

TYPICAL SECTIONS OF IOWA. Owen.	Hall.	MISSOURI.	ILLINOIS.	INDIANA.	KENTUCKY.	TENNESSEE.	ALABAMA.
Magnesian (*b*)	Warsaw.	Boonville.		Bloomington. Spurgeon Hill.	Glasgow.		
Geodiferous Bed (*a*)	Geode Bed, 40 feet.	St. Francisville.	Branches of Ottar Creek. Whitehall, Greene Co. Little Sandy. Scott Co. Above steamboat landing at Warsaw.	Crawfordsville Beds. Indian Creek. Bono. Canton. Brown County.	Clear Creek, Hardin Co.		
Archimedes limestone (*f*)	Keokuk limestone, 40 feet.	Hannibal. Boonville, at water level of the Missouri.	Hamilton. Nauvoo. Niota. Quincy.	East branch Walnut Fork, Montgomery County.			
Shell Beds (*e*)							
Keokuk Cherty limestone (*d*)	Cherty limestone, 20 to 50 and sometimes 100 feet.		Hydes Creek, 3 mi. above Warsaw, thence to Nauvoo, forming lower portion of bluffs at Sagetown, Nauvoo.	New Ross.	Top of Knobs, Bullitt, Marion and Boyle Cos.		

stone,* attaining in Montgomery county, Indiana, a maximum thickness of about three hundred and fifty feet. In eastern Kentucky the rocks occur in the tops of the knobs resting upon the knobstone, in western part of state they thicken up reaching their maximum thickness in Hardin and southern part of Barren counties. Tennessee and Alabama the rocks assume a silicious character and are known as the *Silicious group*, attaining a maximum thickness of not less than five hundred feet.

a. *The Cherty Bed*,

succeeds the Upper Burlington limestone and appears on the Iowa side at the "Cascade" south of the city of Burlington, where the extensive quarrying has developed a great number of fine transition forms of crinoids, from which the bed receives the name of *transition bed* by paleontologists; the bed consists of thin alternating layers of chert and encrinital limestone, and sometimes an intermixture of both. These beds next appear in the river bed above Keokuk forming the "rapids of the Mississippi river" where they attain a thickness of sixty to seventy feet. In Illinois this bed is seen along Hyde's creek three miles to Warsaw, thence to Nauvoo forming the lower part of the bluffs at Sagetown. In Indiana the only equivalent of the bed is found in eastern part of Montgomery county at New Ross where it loses its cherty character, the following section was observed:

Soil	10 to 20 feet
Argillaceous sandstone	3 "
Crinoidal limestone	3 to 9 "
Blue argillaceous limestone	2 to 4 "
Blue shale	10 to – "

In eastern Kentucky, geologists generally apply the name "Keokuk" to the shales and overlying knobstone, which rest upon the Genesee shales, and hold that the knobstone (Waverly) and Burlington groups are absent. At "Button Mole knob" in Bullitt county as well as in the knobs at the edge of the city of Lebanon, Marion county, the knobstone, which Owen pointed out so plainly in Indiana, is well developed, with the equivalent of the Iowa cherty bed with its characteristic brachiopods, resting on top.

*Ohio and Kentucky authors use the Ohio term Waverly; according to the law of priority the name "Knobstone" has precedence as it was applied by Owen in 1838 in his report of the Geological reconnassiance of Indiana made to the Legislature during that year.

Cherty bed of the Keokuk	Limestone.
Knobstone of Ind. / Waverly of Ohio / Chouteau of Mo.	Knobstone / Grey shales.
Devonian	Genesee shale.

Section of Knobs of Bullitt, Marion, and Boyle counties, Kentucky.

b. *The Keokuk Limestone.*

or Lower Archimedes limestone proper of Owen, is best exposed at Keokuk, overlying the cherty beds forming the rapids, and attains a thickness of forty feet. This bed gradually thins out toward the north and at its edges consists of alternations of argillaceous and arenaceous beds with subordinate beds of encrinital limestone. This character is seen to the extreme in the neighborhood of Mount Pleasant, Iowa, and at a less degree at Appanoose, Illinois. In Missouri the bed is exposed at Hannibal and at Boonville, cliffs of this limestone with its overlying equivalent of Magnesian division can be traced from the mouth of Rivière la Mine to below the town, forming a series of wave-like antichnal axes. The following section was observed:

Chert in irregular beds interstratified with beds of shaly limestone and calcareous clay, equivalent of the Magnesian limestone of Owen and the Warsaw of Hall—3 to 6 feet.

Hard blue limestone, containing *Productus magnus*, *P. semi-reticulatus*, *p. punctatus* and *Archimedes owenana*. The Keokuk or Lower Archimedes limestone proper—30 feet.

In Illinois this division of the Keokuk forms the heavy quarry rock at Hamilton, Nauvoo, Niota and Quincy. In Indiana the only equivalent is found on south branch of Walnut Fork in Montgomery county, the following is a section of the rocks:

Soil	10 to 20 feet
Blue shale—containing small pockets of crinoids	5 "
Heavy quarry l.mestone, containing characteristic fossils—seen in the bottom of the creek	2 to — "

In Kentucky the writer has been unable to distinguish this division at any outcrops visited.

c. *The Geode Bed.*

This may be found resting upon the Keokuk limestone proper at Keokuk, consisting of a bed of forty feet of calcareous shale or marl, containing numerous geodes of quartz and chalcedony ranging from the size of a walnut to two feet in diameter, and cavities are usually filled with zinc blende, calcareous spar, etc. In Illinois the rocks have been recognized at Warsaw above the steamboat landing, on the branches of Otter creek, at Whitehall, Greene county, and on Little Sandy, Scott county.

The great number of geodes lithologically characterizes this bed everywhere, in southern Indiana near Bono, Lawrence county, at Canton, Washington county, as well as in the top of the hills in Brown county, this bed may be seen, and the geodes line the sides of the roads. The rocks along Indian creek in southern part of Montgomery county are the exact equivalent of the Canton beds as they contain the same fossils but no geodes.

The writer has also been unable to distinguish this bed in Kentucky.

d. *The Magnesian,*

or Second Archimedes limestone of Owen and the Warsaw of Hall, succeeds the "Geode Bed;" and to this succeed beds of shaly limestone, with partings of shale or marl rapidly disintegrating upon exposure; thickness forty feet. The section is seen above and below Keokuk, Iowa, but much better developed on the opposite side at Warsaw, Illinois. Tracing the formation north it appears at Mount Pleasant.

In Missouri the rocks of this age are seen resting upon the Keokuk limestone proper at Boonville. In Indiana it occurs at Bloomington and Spurgeon Hill, as well as on Clear creek, Monroe county. In Kentucky it outcrops south of Glasgow and at Oil City, Barren county.

On the relation of the Crawfordsville, Indiana beds with the typical locality*.

The Keokuk rocks form the surface of the whole of Montgomery county, with the exception of a narrow strip of later rocks extending into the western part, and are deeply covered with drift so that the only exposures are along the water-courses. The lamination is regular and generally thin, and the general dip is toward the southwest.

The rocks seem to have been deposited and elevated at irregular intervals, giving the same section, but a remarkable difference

*Extract read before the Indiana Academy of Science, December 30, 1891.

in crinoidal life. The rocks cannot be divided into the three divisions lithologically as at the typical locality, and the only way the horizon of the different localities can be determined is by the comparison of the species of crinoids and their exact position in the strata, with species at the typical locality or with other localities whose horizon has been referred to the typical locality with absolute certainty.

The rocks of the different horizons in the county always occur in the following order:

d Argillaceous sandstone.
c Blue shale.
b Encrinital limestone.
a Blue shale

The lowest or Cherty bed outcrops on Raccoon creek two miles southwest of New Roso, where the upper limestone (see section given under a. Cherty Beds) disintegrates in places, weathering out many crinoid remains, the types being characteristic of the Lower Keokuk; several specimens of *Alloprosal-ocrinus*, which is characteristic of the Upper Keokuk, have been found at this locality as well as other localities that are equivalents of the lower beds. Bearing in mind that the rocks of this group in this county were deposited and elevated at irregular intervals, the next series of rocks in ascending order outcrops on the south branch of Walnut Fork four miles east of Crawfordsville, (see section under b. Keokuk limestone).

The limestone resembles very much that at Keokuk, Iowa; it is composed of enormous crinoid stems attaining a diameter of one inch and a length of several feet, associated with large specimens of *Archimedes owenana* Hall, *Productus magnus* M. & W. *P. punctatus* Sowerby, *Platyceras equilatera* Hall, *P. infundibulum* M. & W.

In the shale was found a small nest of crinoids containing a large *Dorycrinus gouldi* Hall, and a very large *Parycrinus* probably a new species.

Again in ascending order the next series of rocks are those outcropping on Indian creek about four miles above the mouth, where is exposed in the bottom of the stream blue shale, underlaid by encrinital limestone; the shale containing large nests of crinoids, several species being identical with those found at Canton, Ind., which is regarded as the Geode Bed: *Actinocrinus* *lowei* Hall, one of the most common species at Indian creek is found in numbers geodized at Canton. Several species have been found at Indian creek that are identical with those of Bono, Laurence Co., Ind., which also is equivalent of the Geode Bed.

Tracing the Indian creek layers northwest seven miles they are found outcropping in the northeast part of Park county on Sugar creek where, together with the higher members of the sub-Carboniferous, they are dovetailed into the Coal Measures.

From the above facts we may consider the Indian creek locality as equivalent to the "Geode Bed." Having established the horizon of the above localities which until 1889 were unknown as prolific crinoid localities, the most difficult question remains to be decided, *i. e.* the determination of the "Crawfordsville beds;" these beds heretofore have been regarded as Lower Keokuk as some of the crinoids resemble Burlington forms.

In excavating at these beds in 1888 this fact was observed that the prevailing types of crinoids found ranging from the level of Sugar creek upward ten feet were the genera *Cyathocrinus*, *Poteriocrinus* and *Barycrinus*; while above these occur the genera *Onychocrinus*, *Forbesiocrinus*, *Gilbertsocrinus* and *Platycrinus;* in Washington county these latter genera of crinoids are found overlying the "Geode Bed" and are identical with those from upper layers at the "Crawfordsville beds."

One mile below the Crawfordsville beds may be seen a heavy layer of limestone containing large geodes about the size of a man's head, and overlying is the equivalent of the "Crawfordsville beds," but diminished to a thickness of only a few feet. At Scott's Eagle Mills, in the northeast part of Park county, the writer has lately traced the Crawfordsville beds as overlying the Indian Creek beds. *Poteriocrinus* reaches its climax in size in the Crawfordsville beds, while the species of *Barycrinus* resemble very closely, if not identical with, the large species found on Walnut Fork.

Alloprosallocrinus, an upper Keokuk species is also found at these beds.

It will be seen by close study of the rocks on Sugar creek that the "Crawfordsville beds" occupy a position between the "Geode Bed" and the Magnesian limestone.

Paleontology.

In the study of the life fauna, especially the crinoidea, of the

Keokuk group, it is readily observed that this series of rocks forms the culminating period of a great crinoidal epoch; that its most ponderous forms occur at its summit, and its base contains the transition forms between this and the Burlington group; there exists a gradual development from the base to the summit.

In 1878 in a paper on "Transition forms in Crinoids," Proceedings Academy of Natural Sciences of Philadelphia, Messrs. Charles Wachsmuth and Frank Springer proposed the name of *Crinoidal limestone* for the Keokuk, and the Upper and Lower Burlington limestones, and clearly proved that these three limestones represent three successive grades of development; Froosts' genus *Agaricocrinus* appears in the Lower Burlington with two arms to each ray, attains its maximum in the Upper Burlington, and becomes extinct at the close of the Keokuk, when it reaches its extravagance of form, and has been found with four arms to all the rays. Roemer's genus *Dorycrinus* appears in the Lower Burlington with a single spine on the apex of the vault, species small, and disappears in the closing of the Keokuk with its extraordinary feature of spines on spines, as represented by *Dorycrinus gouldi.*

NEW LAMELLIBRANCHIATA.

Plate VII.

By E. O. Ulrich, Newport, Ky.

No. 4. Descriptions of one new genus and eight new species.

The greater part of the new forms that have been determined during the progress of my work on the Lower Silurian Lamellibranchiata of the northwest for volume III of the final reports of the Geological and Natural History Survey of Minnesota, now going through the press, were recently published in the Nineteenth Annual Report of that survey. In the last few months much new material has come into my hands, among it several species entirely new to me, and others that were too illy represented in the original lot for description. In the present paper, and in another to follow, the more interesting of these additional new species are described, while the treatment of a few other forms, whose distinctness is not yet fully established, will be postponed till the appearance of the final volume.

CLEIONYCHIA, n. gen.

(*Cleio*, I close, *onyx*, a claw.)

Shell equivalve, subalate posteriorly; beaks terminal, more or less prominent, slightly incurved. Cardinal line straight, rather long, usually forming an angle of less than 90° with the anterior side. Ventral and posterior margins more or less rounded. Surface marked concentrically only, and sloping very gently to the posterior and hinge margins, and proportionately very rapidly on the anterior side. The latter, especially in casts of the interior, flattened or even concave. No byssal opening, the margins closing tightly all around. Muscular impression situated in the postero-cardinal third, large, bilobed, the lower lobe much larger than the upper. Pallial line entire, extending from the muscular scar to the cavity of the beak. Hinge plate edentulous, excavated longitudinally for a linear ligament, with the inner edge thickened and bifurcate at the posterior extremity. A small pit just beneath the beak. Upper part of anterior edge of shell thickened.

Type: *Ambonychia lamellosa* Hall.

This genus will include beside the type and the species next described, *Ambonychia erecta* and *A. attenuata* Hall, from the Trenton of Wisconsin, *A. mytilioides* Hall, from the Chazy of New York, *Pterinea undata* Emmons, and *Ambonychia amygdalina* Hall, from the Trenton of that state. Further, it is highly probable that *A. nitida* and *superba*, described by Billings from Anticosti, and one or two concentrically marked Upper Silurian species referred by Lindström to *Ambonychia*, also should be placed under *Cleionychia*.

As now understood the new genus is distinguished from *Ambonychia* (1) by the absence of radiating plications or striæ, (2) the absence of a byssal opening in the anterior end, (3) the less central position of the muscular scars, and (4) by the absence of distinct hinge teeth.

CLEIONYCHIA RHOMBOIDEA, n. sp.

Plate VII, Figs. 1 and 2.

Shell, as seen in casts of the interior, of medium size, very oblique, rhomboidal in outline, the anterior and posterior and the dorsal and ventral margins subparallel. Dorsal edge nearly straight, likewise the posterior, the two lines meeting at an angle of about 120°. Postero-ventral angle sharply curved, the ventral side gently convex and rounding almost uniformly up into the anterior outline. Beaks terminal, small, projecting, slightly above the hinge line, scarcely incurved. Umbonal ridge strongly convex, extending toward the postero-ventral extremity in a slightly curved direction, so that the slopes on the anterior and ventral sides are more abrupt than on the opposite sides. Point of greatest convexity a little in front of and above the middle.

Interior with the hinge plate rather wide and strong, and the anterior edge, for a short distance beneath the beaks, much thickened inwardly. Muscular scars large, situated about midway in the postero-cardinal half of the shell, the two lobes united by a narrow neck, the upper one oval in shape and about one-third as large as the more nearly circular lower one.

The posterior extremity is more produced and more narrowly curved than in the other species referred to this genus.

Formation and locality: Lower limestone of the Trenton formation at Minneapolis, Minnesota. A single specimen only. This was collected by Mr. J. C. Kassube, and by him donated to the museum of the Geological and Natural History Survey of Minnesota, where it is now to be found under the *Mus. Reg.* No. 5526.

CYPRICARDITES TERMINALIS, n. sp.

Plate VII, Figs. 8-10.

Shell of medium size, moderately ventricose, extremely oblique, with the beaks terminal, rather small, strongly incurved, and projecting but little above the hinge line. Umbo full, and the whole surface neatly rounded. Outline obliquely acuminate-ovoid, with the anterior end narrowly rounded and projecting scarcely, if at all, beyond the beaks, from which the margin slopes backward with a gentle curve into the base; posterior end broad, uniformly rounded; cardinal margin straight, about three-fifths as long as the diagonal length of the shell, rounding into the posterior margin. Surface with faint wrinkles of growth and probably with finer concentric lines. Shell substance thin. Hinge plate rather narrow, with two long posterior and two or three short cardinal teeth in each valve. The latter are difficult to see because of the closely incurved beaks. Anterior mucular impression, as seen in casts of the interior, scarcely visible in a side view, being overhung by the side of the umbo. In an end view they appear like two narrow vertical lobes tapering upward and placed just beneath the free portion of the beaks. The surface of casts is full and rounded.

If *Vanuxemia* Billings, is to be retained for species of this genus having the beaks subterminal, then not only the present but most of the associated species will have to go there. Of the latter *C. rectirostris* Hall, which is exceedingly like *V. inconstans* Billings, is the most abundant and perhaps the nearest to *C. terminalis*, still, the two species are widely different, that one having a strong and thick shell, on the inner side of which there is, as in many other species of the genus, a ridge-like thickening that gives rise to the distinct sulcus and flattening of the beaks on internal casts. In *C. terminalis* on the contrary the shell is thin and without the internal ridge. The beaks are also more incurved than in *C. rectirostris.*

Formation and locality: Lower limestone of the Trenton formation, at Minneapolis and Cannon Falls, Minnesota. Another specimen belonging to the Museum of the Geological Survey of Minnesota was found by Mr. Chas. Schuchert in the "Lower Blue beds" near Beloit, Wisconsin.

CYPRICARDITES OVIFORMIS, n. sp.

Plate VII, Figs. 3 and 4.

Shell rather above the medium size, moderately convex, the outline almost regularly oval, with the posterior end a little the widest, and a slight straightening along the cardinal margin. Beaks small, situated between one-fourth and one-fifth of the length from the anterior extremity; erect, compressed, and not incurved in casts of the interior; in the shell projecting very little if at all above the hinge line. Umbonal ridge indistinct, with the point of greatest convexity a little above and in front of the middle. In the casts there is a more or less sharply defined flattened strip running from the beaks downward. Hinge plate wide and strong, with two strong posterior lateral teeth in each valve, and sometimes a third small one above them, in the left valve. Anterior teeth consisting of one long tooth placed parallel with the margin of the shell in front of the beaks and five or six small unequal teeth running downward from the horizontal tooth. Anterior muscular scar distinct, elongate, vertically disposed, situated immediately beneath the cardinal teeth. Posterior scar illy defined. Shell substance thin except in the anterior and dorsal regions.

The small vertically arranged anterior teeth, and the erect and strongly compressed beaks of casts of the interior, are the two principal peculiarities of the species. These and other equally obvious characters distinguish it from its perhaps nearest congener, *C. obtusifrons* Ulrich. *C. glabellus* Ulrich, from the shales, is wider in front and differently outlined posteriorly.

Formation and locality: Two opposite valves were collected by Mr. Chas. Schuchert, at Janesville, Wisconsin, in the "Lower Blue limestone." These are now in the museum of the Geological and Natural History Survey of Minnesota.

Mus. Reg. No. 8324.

CYPRICARDITES(?) MODESTUS, n. sp.

Plate VII, Figs. 5-7.

Shell small, oblique, moderately ventricose, obliquely ovate in outline, known from casts of the interior only. In these the anterior end is very small, sharply rounded, abruptly depressed beneath the beaks, and almost entirely occupied by a subcircular muscular scar. Beaks small, only slightly incurved, appearing prominent from the front but not from the back. Umbonal ridge scarcely distinguishable, the cardinal slope faintly concave between it and another low ridge-like swelling that forms the back of the cast. Along the hinge line there is a narrow impressed area. Shell thin; hinge-plate narrow; dentition undetermined.

The generic position of this shell is doubtful, I having thus far failed in my efforts to make out the dentition of the hinge. From the narrowness of the hinge-plate I am satisfied that there cannot be more than a single posterior lateral tooth, if any. It is possible that the species is a *Matheria* with relations to the *M. rugosa*, recently described by me from a lower horizon in the shales, in which the anterior muscular impression is as in the present species deeper than usual in that genus. It is clearly, I think, not a *Modiolopsis*, and until more is learned of its hinge it seems best to arrange the species as above.

Formation and locality: Lower half of the Galena at Oshkosh, Wisconsin, and several localities in Goodhue county, Minnesota.

Collectors, Chas. Schuchert, W. H. Scofield, E. O. Ulrich.

TECHNOPHORUS SUBACUTUS, n. sp.

Plate VII, Figs. 13 and 14.

Shell small, rather ventricose, alated posteriorly, the hight and length respectively as two is to three. Cardinal margin nearly straight, anterior end uniformly rounded, ventral edge more gently curved, the posterior straight and sloping backward slightly to the acuminate extremity of the hinge line.

In a cast of the interior the small beak is erect, projects prominently above the hinge line, and is situated about one-third of the entire length from the anterior extremity. Just in front of the beak there is a strong and deep impression, running almost vertically downward. On the anterior side this slit margins a rather large muscular scar. Extending backward from the beak the cast exhibits another, but in this case very obscure linear depression. Two curved folds, the posterior one the strongest, extend from the postero-ventral angle toward the beaks, becoming indistinguishable, however, about midway between the two points. Surface markings and hingement unknown.

Length 11.5 mm., hight 6.8 mm., convexity of one valve about 2.2 mm.

This species is intermediate between *T. faberi* S. A. Miller, the type of the genus and *T. extenuatus*, recently described by the author from the lower part of the Trenton shales of Minnesota. In the first the posterior end is shorter and produced below instead of above, in the second the shape is quite different and the posterior end more drawn out. A nearer congener than either of these, but one that is as yet undescribed, occurs at Cincinnati, Ohio.

Formation and locality. Upper part of the limestone of the Trenton formation at Minneapolis, Minn.

Museum Geol. Nat. Hist. Sur. Minn.; Reg. No. 8338.

TECHNOPHORUS FILISTRIATUS, n. sp.

Plate VII, Figs. 11 and 12.

Shell small, though large for the genus, compressed, with the greatest convexity in the anterior half, scarcely alate posteriorly, the hight and length as three is to five. Beaks small, projecting very little, slightly incurved, one-third of the entire length of shell from the anterior extremity. Anterior end much the widest, broadly and uniformly rounded except above where the curve turns rather sharply into the hinge line. Ventral margin rounded in front, straight and sloping upward in the posterior half to the acute extremity. Posterior margin short, straight, sloping forward. Cardinal margin straight except for a slight prominence in the region of the beaks. Anterior half of surface marked with closely arranged, thread-like, concentric lines. These seem to be wanting in the posterior half, only a few obscure growth lines being visible here. Posterior ridge sharp and strong, very gently curved in its course from the beak to the produced lower angle of the posterior extremity of the shell. Between this ridge and a line drawn vertically across the shell from the beaks the surface is depressed, forming a widening shallow sulcus and the straightening of the ventral margin. Postero-cardinal slope concave, narrow, descending rather rapidly. Interior unknown; shell substance very thin.

Length 21 mm., hight 12.5 mm., greatest convexity (of a left valve) 2.5 mm.

Although the internal characters are as yet unknown, the data obtained point very strongly toward Miller's *Technophorus.* Compared with *T. faberi* Miller, the posterior end will be found to be longer and narrower, while there is only one posterior ridge where that species has two. *T. extenuatus* Ulrich, another species from the Trenton shales of Minnesota, agrees closely in all respects except that it has the posterior end greatly produced.

Formation and locality: In beds regarded as equivalent to the "Upper Buff limestone" of the Wisconsin geologists and the Black River limestone of New York, six miles south of Cannon Falls, Minnesota. This horizon contains an interesting fauna, consisting chiefly of Lamellibranchiata, Gastropoda and Cephalopoda. It follows layers filled with bifoliate Bryzoa and is succeeded by soft shaly beds in which the predominant fossils are *Phylloporina corticosa*, *Prasopora* and numerous other Trepostomata, and one of the so-called "branching fucoids."

TECHNOPHORUS DIVARICATUS, n. sp.

Plate VII, Figs. 15 and 16.

Shell small, moderately convex, elongate, the length a little more than twice the hight. Beaks small, incurved, projecting but little above the hinge line; situated about one-third of the entire length from the anterior extremity. Dorsal margin nearly straight, (faintly concave on each side of the beaks) about three-fourths as long as the shell, terminating abruptly where it joins the concave posterior edge, with the upper part of which it forms an angle little short of 90°. Anterior end a little the widest, strongly convex, especially above; below rounding neatly into the at first gently convex, then straight and finally concave basal line. Posterior ridge thin but very prominent, curving slightly in its course from the beak to the sharply produced postero-basal angle. Surface uniformly convex, and marked with fine, thread-like concentric lines in the antero-basal three-fifths, beyond which it first descends into a sulcus and then ascends sharply into the ridge, dropping on the other side even more abruptly into the wing-like postero-dorsal part of the shell. On each side of the posterior ridge there are distinct divaricating lines, twice as strong as the concentric lines on the anterior part of the shell. They join each other on the ridge, and, those on the lower side of the latter, the concentric lines at angles of about 70°. Finally, there is another set of such lines along the dorsal edge, running parallel with the set on the lower side of the ridge. Internal characters unknown; shell substance very thin.

Length 12.5 mm., hight at the beaks 5.8 mm., hight at posterior end of hinge 5.1 mm., greatest thickness of closed valves 4.1 mm.

Casts of the interior would be distinguished by having the dorsal and ventral margins more nearly parallel than is the case in any of the other species referred to the genus. With the shell in a good state of preservation the species is distinguished from all Silurian lamellibranchs by the peculiar surface ornamentation.

Formation and locality: Near Cannon Falls, Minnesota, in the "Phylloporina bed" of the Trenton shales.

TELLINOMYA LONGA, n. sp.

Plate VII, Figs. 17 and 18.

Shell small, compressed, elongate, elliptical, the length equalling a little more than twice the greatest hight. Beaks small, situated about one-fourth of the entire length from the anterior extremity. Cardinal line, on the whole, very slightly convex, straight behind the beaks; anterior end short, semi-circular; ventral margin gently convex; posterior end a little narrower than the anterior, and more sharply rounded. Surface with obscure concentric lines; sloping rapidly at the cardinal margin but very gently to the ends and ventral edge. Hinge plate of moderate strength, bent a little beneath the beak, and with a thickening on the lower side in front of same. Posterior to the beak the plate is long, straight, and bears twenty or more small teeth, while on the anterior part only nine are to be counted. In the vicinity of the beak the teeth, especially those on the posterior side, are very small. Anterior muscular impression deep, situated immediately beneath the end of the hinge. Its posterior side is defined by a strong vertical thickening of the shell. Posterior scar distinct, but less sharply impressed than the anterior, situated at the end of the hinge just within the thin postero-cardinal border of the shell.

Judging from the interior this shell, though more elongate, evidently belongs to the section of the genus of which *T. ventricosa* Hall, *T. angela* Billings, *T. contracta* Salter, and *T. planodorsata* Ulrich, are typical members. In all of these the muscular scars are deep and large, excavating the shell under the ends of the hinge plate so that they are exceptionally prominent in casts of the interior.

Formation and locality: In shaly strata, equivalent to the Black River limestone, at a point about eight miles south of Cannon Falls, Minnesota.

EXPLANATION OF PLATE VII.

Figs. 1 and 2, CLEIONYCHIA RHOMBOIDEA, n. sp.

Lateral and anterior views of a right valve.

Figs. 3 and 4, CYPRICARDITES OVIFORMIS, n. sp.

Anterior and lateral views of a cast of the interior of a left valve, the posterior outline restored.

Figs. 5-7, CYPRICARDITES (?) MODESTUS, n. sp.

5. Left side of a cast of the interior, × 3.

6 and 7. Left side and anterior views of same, natural size.

Figs. 8-10, CYPRICARDITES TERMINALIS, n. sp.

8. A left valve from the limestone at Minneapolis, natural size. No. 5,100 of the Mus. Reg. of the Geol. and Nat. Hist. Surv. of Minnesota.

9. A right valve from a similar position at Cannon Falls, Minnesota.

10. Anterior view of these two valves.

Figs. 11 and 12, TECHNOPHORUS FILISTRIATUS, n. sp.

A left valve, natural size, and the antero-basal portion, × 3, to show concentric lines.

Figs. 13 and 14, TECHNOPHORUS SUBACUTUS, n. sp.

13. Cast of a left valve, natural size.

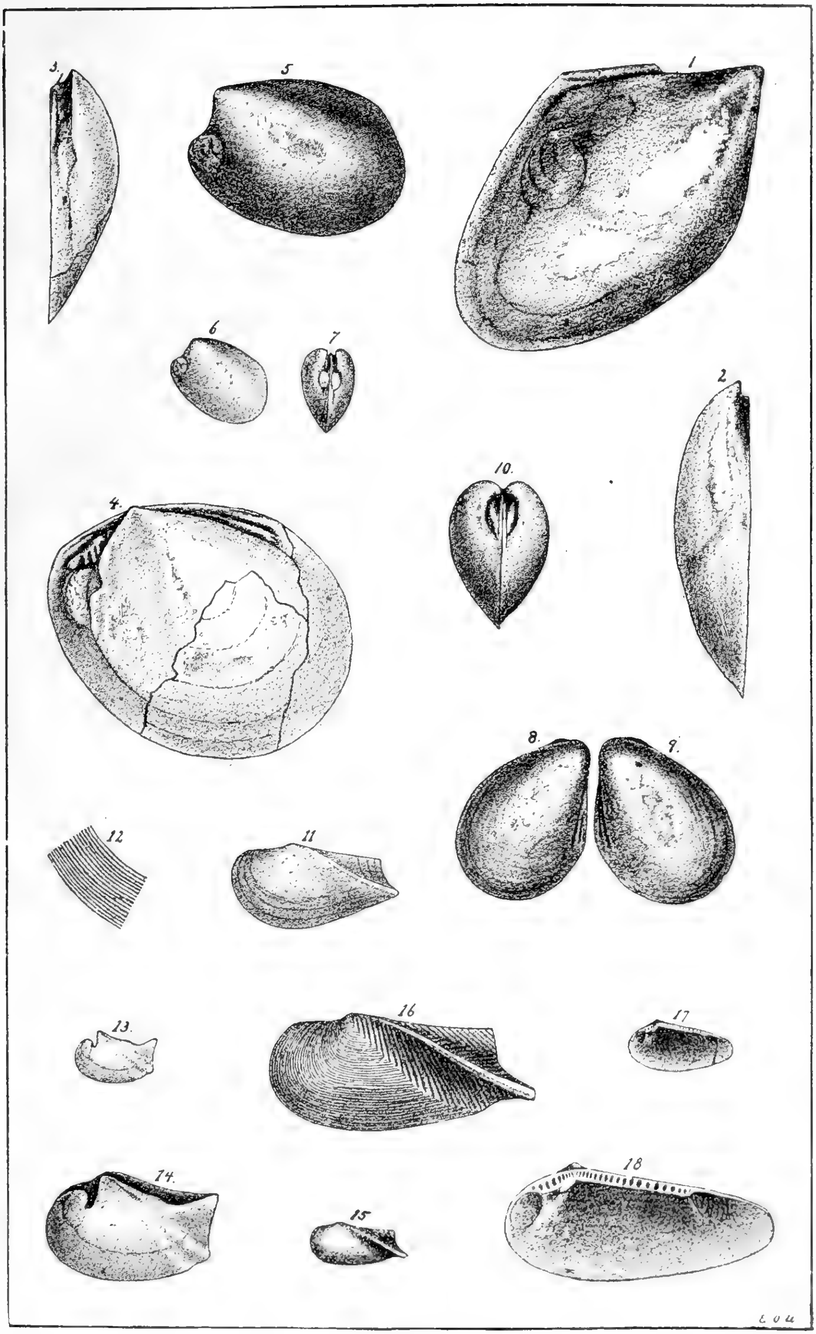
14. The same, nearly × 2.5, with the impression of the hinge and internal ridge.

Figs. 15 and 16, TECHNOPHORUS DIVARICATUS, n. sp.

A left valve of the natural size and × 3.

Figs. 17 and 18, TELLINOMYA LONGA, n. sp.

Interior views, of the natural size and × 3, of a right valve.



NEW LAMELLIBRANCHIATA.—Ulrich.

THE GEOLOGIC EVOLUTION OF THE NON-MOUNTAINOUS TOPOGRAPHY OF THE TEXAS REGION. AN INTRODUCTION TO THE STUDY OF THE GREAT PLAINS.*

By Robt. T. Hill, Austin, Texas.

East of the Pecos river the topography of Texas is a vast series of plains and drainage valleys eroded into plains. It is characterized by a sub-horizontal structure of diverse terranes, the most extensive of which are of Neozoic, post Paleozoic age.

Approached from the northwest the "Staked plains" are a continuation of the Great Plains of central United States, which separate the Rocky mountain front from the Mississippi valley, and are composed of Miocene strata. In the eastern border of the state the plains are a continuation of the great coastal plain of the Atlantic and gulf region. Each has its own topography, flora, fauna, and cultural conditions and, in general, a substructure of horizontal strata void of mountain folds and corrugations.

In the south of the state the great plains of Colorado meet and show their relation to the coastal plain of the Atlantic.

Across the centre of Texas from the Rocky mountains at Las Vegas, New Mexico, to the coast at Galveston, a profile and section can be constructed which will reveal in detail the history of deposition and degradation of the region, including two great periods of eruptive activity.

Portions of this section show for long distances a monotonous uniformity, but in the fifty miles on either side of the capital is revealed a comprehensive view of all the formations from the alleged Archæan and Algonkian to the present time.

The only formations immediately bearing upon the origin of the plains—both coastal and great—are of Neozoic origin, which, as a rule, may be considered the product of alternate subsidence and elevation accompanied by the invasion and recedence of the gulf of Mexico.

During these time-intervals the processes of land degradation and coastal sedimentation together with changes of climate varied so as to produce the specific differences now existing in composition of formations, residual soils, consequent drainage growth and resultant topography. Before giving the details of these processes of Neozoic time it may be proper to review our limited knowledge of the topographic features which existed at the close

*This article is a continuation of my chapters on the Geography and Topography of the Texan Region, published in this magazine.

of Paleozoic time; a period during which our continental outlines underwent their most radical changes and, for this region at least, the evolution of modern topography began. The eastern half or Appalachian outline of the continent was approximately defined east of the 97th meridian. Another but as yet obscurely defined land or islands existed in the region of the western Cordilleras (the Rocky mountain, Great Basin and Sierra regions). Between these main continental areas was the region which has since been evolved into the Great Plains, and is supposed to have been a vast enclosed basin extending far southward from the southwest corner of Appalachia. Through the heart of Texas was a long narrow isthmus or peninsula of post-Paleozoic land against whose western shore were laid down the vast "Red beds" formation of Permian, Triassic, and probably early Jurassic time. The rock structure of this strip of land was of Carboniferous and earlier age; it generally dipped westward or in a direction diametrically opposite to the great series of Neozoic sediments later deposited, from early Cretaceous to the present, which from their general dip to the gulf may be termed the coastward incline.

The Paleozoic rocks of central Texas, although continuous in extent, are exposed as two distinct areas separated and covered by a remnantal mass of Mesozoic rocks, which now occupy the divide of the Brazos and Colorado rivers, and once continued entirely over them. The northern area, so far as exposed, consists of Carboniferous-Permian rocks. In the southern or Burnet area erosion has cut deeper into them, exposing successively lower rocks down to the Algonkian. There has been no permanent land area of Archean or Paleozoic rocks in this region since Mesozoic time, for they were completely covered by subsequent sheets of deposition, and now occur in a valley of erosion surrounded on every side by the horizontal scarps of the Cretaceous, down which the drainage flows to the centre of the alleged Archean land. Thus are exposed the successive older rocks—Carboniferous, Silurian, Upper Cambrian,—and in the lowest drainage valley the Algonkian is reached. If this had been a persistent land area it would not have been covered by Cretaceous sediments, and the drainage would flow outward from it instead of downward into it.

This north and south strip of Paleozoic rocks, which is now becoming exposed across Texas, is an important factor in the evolution of the plains topography, for it has been influential in partially outlining the present surface features.

After the close of the Carboniferous, and continuing through the undetermined period of the Red Beds epoch, this Paleozoic tongue was a land barrier extending south and east, an undefined distance; it drained westward into a great interior basin, now only indefinitely known by the extent of the Red Beds sediments which are in part derived from it. There is no trace of an eastward flowing drainage, for the eastern projecting edges have been planed off by the numerous subsidences it has since undergone, and the sediments of the Red Beds epoch are not present.

It is evident that this land barrier, which kept the marine waters of the gulf from the Great Plains region in Permo-Triassic time, was gradually degraded, and the great basin between it and the Rocky mountain area filled in, thus preparing the way for the free invasion of the Great Plains region by marine waters during the subsequent epochs of profound subsidence.

At the beginning of Lower Cretaceous time, during the Wealdan epoch, as is accurately determined by fossil plants, molluscs and vertebrates, a profound subsidence began, during which, the narrow strip of land was completely base-leveled, and the marine waters of the gulf swept west and north over the entire state of Texas to the Cordilleran continent and the first marine invasion of at least a portion of the Great Plains occurred. It was during this epoch that the calcareous sediments of the Comanche series were deposited, which now form the most conspicuous feature in the topography and structure of the Texas Mexican region. During the deposition of these beds, the first half of Cretaceous time, the oceanic waters covered all of the Texan, West Indian and Mexican regions, and the northwest corner of South America. The shore line was around the southern front of the Colorado group of the Rocky mountain nucleus, extending eastward along the base of the Ouachita group of southern Indian Territory and Arkansas to the end of the Appalachians, around which it deflected northward via Washington, coinciding with the known limits of the Potomac formations.

At the close of the Comanche epoch another uplift of the continent ensued, the ocean waters receded nearly to their present outline, and the processes of land degradation were again accelerated.

Once more the loading of the coastal plain began, and the sediments of another great formation were laid down. This was the Upper Cretaceous formation or the familiar Meek and Hayden section. Subsidence began again while the ocean receded interiorward; the Texan and Great Plains regions, with much of the present Rocky mountain region, were covered with 2,000 feet of sediment.

The remnantal outcrop of this great formation is shown upon the maps. Its sediments record the sequence of events as the Lower Cretaceous; that is (1) basement littoral beds of sand, (2) deeper beds of clay, calcareous in their upper portion, (3) a deepest stage of almost pure chalks, (4) beds shallowing towards the top.

How much of the Comanche series was destroyed by base-leveling during this epoch can only be surmised.

At the close of the Upper Cretaceous the most marked uplift of the Rocky mountain region took place, and the ocean's waters again receded nearly to their present outline. Again land degradation and deposition began, resulting in the third loading down of the coastal plain, followed by the cycle of deposition and subsidence of the Eocene epoch.

During the basal Eocene the central Texan region was covered; how far and to what extent is problematical, but another heavy load was added to the coastal plain.

The great hiatus in the geologic history of the region is of Neo-Pliocene time, between the close of the Eocene and the beginning of the Appomattox. The present state of ignorance allows but little to be said of it.

It is not known whether at the close of the Eocene there was any important event, such as the elevation or subsidence of the coastal plain. We have knowledge of only the basement history of the marine Eocene. Its upper contacts or gradation have never been studied or presented.

It is known, however, that in Miocene or Pliocene time another shore line had developed along the Rocky mountain front, into which flowed the drainage of the Rocky mountain region, and all the vast region between the Rocky mountains and the coast was once more laden with sediments, and later these plains were elevated into the dry land which they have since remained; they present a vast sheet of sediments upon much of which drainage channels have not yet been established, but so degraded and eroded upon its eastern edge, that their former extent in that direction has not been determined. No portion of the geologic record is more obscure than that of the conditions of the coastal region during this Mio-Pliocene epoch. Whether the Llano Estacado formation, which now covers and is co-extensive with the Great Plains region, was laid down at marine or lacustral base level is an important question; if at the former there should be some record in the coastal formations now remaining; if at the latter there should be structural or topographic evidence through the central Texan region of a land barrier which separated the lacustral from the gulf waters. After careful study the writer has so far been unable to find corroborative evidence of the lacustral theory while there is abundant evidence of the identity in origin of certain coast deposits with those of the Great Plains region.

With the close of the unstudied Mio-Pliocene epoch history again becomes clear, and during late Pliocene, Pleistocene and recent times there is a remarkable continuation of alternations of loading down and degradation of the coastal plain, and the initiation and life history of the present topographic forms and drainage system.

At the close of or during the Llano Estacado or Mio-Pliocene epoch occurred an event which has given a peculiar configuration to southwestern Texas. Under the weight of the increasing and successive accumulations of coastal sediments, a great fault line developed extending nearly across the state from Austin to Del Rio, the down-throw being to the east. The scarp line thus evolved became the shore line for the subsequent Appomattox sea; erosion attacked it with increased activity, but, owing to conditions of aridity, with relatively small effect.

During the Appomattox epoch, which is located by its discoverer, Mr. McGee, in late Pliocene, the long degraded land of earlier Miocene and Pliocene again subsided; but the shore line as delineated on the map extended across only one-third of the state, passing via Texarkana, Austin and San Antonio, west of Eagle Pass to the Rio Grande.

Before this epoch two river systems had been developed, and they remained distinct features of the landscape. The older system included those streams which at the culmination of the Mio-Pliocene subsidence were mountain streams debouching near the present Rocky mountain front, and which under apparently very arid conditions extended their mouths seaward with the receding waters, across the Great Plains region; the Canadian and Pecos rivers are examples of this system. The system, second in age, included those rivers originating in the uninterpreted interval between the close of the Great Plains epoch and the beginning of the Appomattox,—the Colorado, Brazos, and Red belong here.

During the culmination of the Appomattox a third and distinct system of drainage was evolved along the then low lying coastal plain, adjacent to and interior of its shore line. This group of rivers is easily traced upon the maps and includes the San Gabriel, Lampassas, Leon, the Bosques, Paluxies and Trinities. They are short streams not exceeding 100 miles in length, and drain the ancient structural or dip plain of the Grand Prairie, or Lower Cretaceous region. Their profile in relation to the plains which they drained are as shown upon the diagram, and they are relatively 500 feet higher at their heads than the adjacent and more deeply cut drainage of the first and second systems. The debouchement of these streams during Appomattox time is clearly marked upon the map by the great estuarian deposits, as shown by the river terraces especially of the Colorado where it emerges from the canons of the Grand Prairie (Appomattox land) into the Black Prairie (Columbian coastal plain). The sea receded and the submerged plain of Appomattox became dry land. The sea shore reached about one-half the distance between the present coast line and the ancient Appomattox shore. This was the Columbian epoch of Pleistocene time. Upon the new land, the present coast prairies, still a fourth system of coastal drainage, was initiated almost similar in extent and aspect to that of Appomattox time. The rivers of the third or Appomattox system were extended to the Columbian shore, while those of the second or Colorado, Brazos, pre-Appomattox type became long estuaries back to the Appomattox shore line; at the close of that period change in the direction of slope caused them to form a line of junction with some adjacent stream, either with one of the older streams or with one another. These streams were accelerated by the elevation at the close of the Appomattox and Colorado, and have since cut deeper but proportionately less channels than the more voluminous streams of the older systems.

Few of these streams have crossed by headwater erosion the great western scarp of the Grand Prairie; at present this portion of their development seems retarded for where they have crossed the western scarp line it has been by capture—by the laterals of the older streams.

The Columbian deposition plain, the present coastal prairie, in turn became dry land by the recedence of the gulf to its approximate present coast line; upon this recently submerged area was developed the latest and newest drainage system of the region, a fringe of small streams flowing directly into the gulf of Mexico, readily traced in the present Coastal Prairie region.

At the close of the Columbia there was another upward movement of the continent. The streams of systems 1, 2, 3 and 4 were again accelerated by an increased gradient and the prolongation of the coastal ends renewed.

It may be well to review the present condition of the systems.

Those of oldest or Miocene origin, for instance the Canadian and Pecos, in their youth drained the limited Rocky mountain and Plateau region, attained base level near the present front of the Rocky mountains, still receive their greatest drainage from the original receiving area and practically flow long distances without receiving any of the later developed drainage. In early Pliocene time their base level receded eastward with the shore line.

With all the oscillations of elevations, invasions, and recedences of the sea shore, these streams have continued to carry their loads of mountain sediments to the sea, until to-day they are merely long viaducts receiving most of their supply at their heads and draining little of the country through which they pass.

At some yet undetermined time in history the Rio Grande, which was a great interior basin stream, cut its way across the continued axis of the Rocky mountain system and joined the Pecos; the writer inclines to think this was earlier than the Pleistocene and that through the water gap of the Rio Grande the great lakes of the basin region had a partial outlet to the sea.

The rivers of the second system—the Red, Brazos, Colorado—have since their origin in the obscure epoch between Miocene and Pliocene time been at work upon the coastal plain developed at the close of the obscure Staked Plains or Mio-Pliocene epoch; their drainage with each succeeding event has degraded larger and larger areas. The coastward extension of these streams following the receding shore lines is also shown in the medial portions of their courses. In Appomattox time they received none of the new lateral drainage which flowed down the slopes coastward and parallel to them. With each oscillation of base level their work has been retarded or accelerated until they have stripped vast regions in the active head-water areas and cut far below the level of the newer systems through Miocene, Eocene, Upper and

Lower Cretaceous floors to the Algonkian or Archean, which the Colorado is now eroding.

During the Appomattox the mouth of the Colorado was at Austin; during Columbia it reached base level at the same place, but continued a long estuary, like the Potomac, to the eastern coast; in post Columbian times it took a new channel from the Columbia to the present shore line; its old course is preserved as lakes and bayous; interior of that line it was twice superimposed upon its old channel.

Let us consider the drainage in relation to its task in denuding the land. In general, the divides of the Texas streams are flat-topped plateaus representing original deposition or consequent degradation plains over which head-water ramifications of the streams have not completely extended. In but one portion of one system does a state of completion exist, *i. e.* the condition in which the head-waters of opposing streams have reached across the plateau and etched away the original deposition level. This area is the northern half of the central region, or the area in which the Paleozoic and Red Bed rocks are now exposed, to which in the author's earliest paper upon Texas, the name Central Denuded region was applied. Since the close of the Miocene Plains epoch, when the waters receded from the Rocky mountain front, it has remained an unsubmerged border-land, interior of Appomattox, Columbian, and present shore lines; degradation has been constantly at work upon it and erosion has cut through successive sheets of the Plains formation, the remnantal Upper and Lower Cretaceous and, in part, the Carboniferous to the alleged Archean.

The Appomattox or Grand Prairie streams are approaching completion; and in a few places their headwaters have cut through the flat-top divides between them; they are rapidly approaching maturity as shown by the butte and mesa type of divides.

The streams of the Columbian epoch are adolescent, but have done much work in the softer deposits of the Eocene area.

The streams of the present epoch on the emerged Columbian deposition plain are nascent or just beginning their life work.

Extended portions of the older systems, *i. e.*, those portions of the Rio Grande, Pecos, Red, Canadian, Brazos, and Colorado, whose mouths extend oceanward with the receding coastal line without draining the area through which they flow, are still doing their greatest work in their distant sources and merely cutting deeper channels in the areas through which they extend.

Let us return to the part played by the ancient Paleozoic floor in this chapter of events.

Extending across the heart of Texas from north to south as a low lying barrier between the gulf and the interior post-Paleozoic seas, it was so base leveled and degraded that when the profound Cretaceous subsidence began it was buried beneath thousands of feet of off-shore sediments, but of a softer, and more easily degraded nature than the firm granitic, hard limestone and quartzite beds of the Paleozoic, which especially composed its lower part and southern end.

In the great series of loading down the coastal plain coastward of it, and the consequent oscillation of elevation and subsidence of the vast plains region, it was natural that this solid core of Paleozoic rocks had greater resistance for the accompanying strains and stresses, and finally under continued loading the great balcones fault developed approximately along the coastal margin, leaving sharp projecting land adjacent to the Appomattox sea upon which degradation was facilitated; this has partially removed its Neozoic covering, and will ultimately degrade it to base level.

The topography of the Texas plains is the product of the etching of a series of sedimentation plains of post Eocene age by a series of consequent autogenetic drainage systems. The plains are the product of the oscillations of the Cordilleran continent, whereby the waters of the gulf and accompanying base leveling swept back and forth across the Texan region. These oscillations began with the overcoming of the central Paleozoic barrier at the beginning of the Comanche or Lower Cretaçeous epoch, attained their maximum in Upper Cretaceous time, as recorded in the Dakota base leveling, when the sea extended over much of the present Rocky mountain area. In Laramie-Eocene the oscillation was almost as profound and far reaching. Following that epoch was decreasing intensity; the line of marine base level extended less and less inward during the invasions of Miocene, Pliocene, and Pleistonic time.

Dependent upon conditions of deposition the rocks of these different periods are of different degrees of consolidation, and consequent resistance to denudation.

In the Neozoic series, however, there are but three formations sufficiently consolidated to produce canoned or scarp topography—the iron ore beds of the Eocene, certain white rock beds of the Miocene or Llano Estacado, the Fayette beds, and the limestones of the Comanche series.

The first two—the Eocene iron beds of east Texas and the Miocene beds of the Staked Plains—are thin horizontal beds of consolidated material underlaid by loose friable beds which rapidly disintegrate upon the removal of the cap sheet and produce mesas. These mesa products are not greatly developed in East Texas because of the newness of the streams, but in the Llano Estacado are very marked.

The great chalky limestone formation of the Comanche series has been the chief factor of resistance to sculpture in the Texas region, and the effects produced by erosion of its alternations of hard and soft beds are both beautiful and instructive. Along its eastern margin where it dips beneath the Upper Cretaceous its prevalent forms are dip plains and escarpments of stratification extending north and south; many streams flow along them in the same directions until they cut their way through the escarpment, when they again flow eastward to the sea. In the west central portion of the state headwater erosion of opposing streams has produced numerous buttes and mesas, which are often a hundred miles from the mother area of which they were a part.

While the general coastward direction of the streams is the result of the prevalent slope, there are certain influential structural features which in the aggregate produce the prevalent topographic detail.

First of these are joints and faults.

The stratigraphic system of this region is broken by a system of complemental joints which have a major axis of west of south to east of north or sub-parallel to the coast line. In areas of unconsolidated chalks, sands, and clays, joints have no perceptible effect in deflecting streams, but where the material is consolidated streams adapt their courses to joint lines; this is shown by the Brazos in the Carboniferous rocks of Palo Pinto county, the Colorado in the Lower Cretaceous of Travis, and in other instances.

In only two cases have great faults developed in the direction of these joint planes. One—the great Balcones fault from Austin to Del Rio—has a downthrow to the east and at right angles to the streams; except a slight deflection of the Colorado west of Austin, it has in no way affected the course of the streams.

The other exceptional fault extending from Marietta, Chickasaw nation to south of Texarkana has its downthrow interiorward, and Red river follows its trough for many miles, and its direction is primarily influenced by it.

The area is too vast to give details of many of the propositions I have set forth, or to call attention to several minor topographic processes. There are two agencies which cannot be passed, however, which play a more important factor in the Texan region than elsewhere in the United States, and these are wind and aqueous solution. Owing to aridity and lack of consolidation, the crumbling structure is readily transported by wind, dust and sand storms being of great frequence. In bluffs and canons, composed of alternating structure of consolidated and marly layers, the former are undermined by wind erosion.

Over the vast and intensely heated limestone plateaus, solution plays a most important part, and there results a remarkable weathering of the limestones into miniature mountain ranges, and a corresponding deposition of that remarkable calcareous deposit known in Mexico as tepetate.

NOTES ON EARTHQUAKES IN NICARAGUA, FEB. 6, 1892.

J. Crawford, Leon, Nicaragua.

At 10 h. 10 m., p. m., 6th February, 1892, occurred an apparently connected series of about 92 seconds total duration, of longitudinally oscillating, progressive, spherical, seismic waves [$y=a \sin (Pt—nx)$....] that passed northwestwardly and southeastwardly in Nicaragua, parallel with, and along or near to, the volcanic masses which extend connectedly with but a few short interruptions, (as across the bay of Fonseca and lakes Managua and Nicaragua), between the volcanic groups in the states of Salvador and Costa Rica.

The facts obtained, in reference to this earthquake, to date—the sailing of the weekly Mail S. ship from the port of Covinto—5 o'clock p. m., 9th February, 1892, are:

Only one series of vibrations has occurred. The epicentrum was near the island of Zapatera at the west coast of lake Nicaragua, distant about 14 miles east from the Pacific ocean and about 28 miles southeast from the city of Granada.

The focus has not yet been determined, but was more than 15,500 feet (English) beneath a plane parallel with the sub-areal surface of the Pacific ocean.

The co-seismal lines of emergence of the waves, at the earth's surface, were elliptical, but converging at several places toward the longitudinal axis of the ellipsoid.

The maximum of the horizontal element of the oscillations, or line of greatest disturbance at the earth's surface was, on the northwestern side of the epicentrum, in lake Managua, about 65 miles distant from the point of first emergence, 30 miles westward from the city of Managua, and about 36 miles southeast from the city of León.

The rate of transit through the earth during the latter or vibrating part was about 29 miles per minute.

The greatest vibration, in the city of León, from a line perpendicular to and at an altitude of 60 feet above the surface was 9° 25′ about.

Several adobe walls of houses in the cities of Granada, Managua, and León were slightly cracked, or, these walls (usually 2¼ to 3 feet (English) thick and 14 to 18 feet high) were disconnected from similar ones connected at right angles, *i. e.*, those extending north and south were slightly disconnected from those extending east and west.

The city of Managua being nearer the coseismal line of greatest force expressed at the surface than the other cities named felt this earthquake more severely. In the city of León, the locality of the longest ordinates of the curvatures, or apex of elevation and depression, were easily discovered by finding the walls of houses that had been slightly displaced or cracked by the waves.

During the first 60 seconds the oscillations were about one each six seconds—causing a sensation as if they had originated from the impact against the hard floor of some deep seated cavern of large masses of hard strata; there was felt a perceptible increase and decrease of the oscillations; then, for about 32 seconds were experienced more rapid or vibratory movements of short, high waves as if two large masses of rock had (at an interval of about 15 seconds) suddenly separated from their places and fallen to the hard floor of a cavern, from a hight sufficient to cause a slight jar, each 90 miles distant, and converting the energy into elastic, longitudinally vibrating, progressive, spherical waves of force.

No place has been discovered where permanent subsidence of the earth's surface has resulted.

This earthquake was not caused by volcanic forces such as the superior energy of high tension gases or aqueous vapors disarranging earth strata.

The aqueous vapors arising from the cones of the nearly exhausted volcanoes on the line of force [Santa Clara, Momotomba, and Omatepa] have not increased nor diminished in apparent quantity.

No perceptible change has been observed in the amount or the temperature of large springs of water, issuing from fissures, near the base of some of the volcanic cones, on the line of force, in Nicaragua.

The primary cause of this class of seismic disturbances in the earth's crust in this region can be discussed hereafter when all the phenomena referable to this series have been studied. At present two theories—each with some good evidence—are presented: *First,*—Motion from the interior friction of "the bodily tides" [Prof. G. Darwin, Philo. Transt. 1879, parts I, II,] incident to the increased length of the siderial day and, probable, consequent elongation of the earth's polar radius and increased pressure in equatorial latitudes. *Second,*—Contraction from secular cooling and the consequent increased tension in the narrow strip of land, between the line of volcanic masses in Nicaragua and the Pacific ocean, acquiring sufficient force to overcome the cohesion and disconnect large masses of strata and precipitate them into adjoining caverns deeply located beneath the volcanic cones and masses of ejecta. This "sufficient force" appears to have attained its maximum *annually*, or, at intervals of 10 to 14 months during the past four years, as observed by the writer, in this part of Nicaragua, a short series of earthquakes having occurred annually.

There has been a subsidence, occasioning plications or foldings of the strata, in western Nicaragua, between the Pacific ocean and the line of volcanic cones, (a strip of land 27 to 33 miles wide,) whether paroxysmal and expressed in earthquakes or continuous—has not yet been determined. This subsidence is now in progress, and its phenomena are being studied by the undersigned. J. CRAWFORD.

Leon, Nicaragua, 9th February, 1892.

POSTSCRIPTUM. Since mailing on 9th instant, "Notes on Earthquake phenomena in Nicaragua" on 6th instant, I learn, by telegraph, as follows, in reference to the approximate length and width of the ellipsoid and the line of greatest disturbance at the earth's surface:

(a) The seismical force followed the volcanic belt southeastwardly into Costa Rica, and more severely south than north of the epicentrum, as if accummulating disturbing forces as it traversed the sub-terranean parts of the group of active and of "hot" volcanoes in that country.

(b) The line of greatest disturbance curved irregularly in its southern course—first southwestwardly, between the city of Rivas and the Port of San Júan del Sur, in Nicaragua, thence southeastwardly near the Pueblo of Philadelphia in northern Costa Rica and along the line of volcanic masses to near the city of San José (quite severe), thence, (so far as I have information to date) southeastwardly into the Caribbean sea.

(c) The length of the disturbance of this series of seismic waves has been traced for over 500 miles and the average width of their disturbance about 100 miles.

(d) Electro-magnetic phenomena, to be described hereafter, were quite prominent.

(e) The retardation of the waves in—and their greater disturbance of—some kinds of strata can be traced at several places, also, have been noted a few places where they were reflected from the strata and two or three places where, apparently, there was interference of waves and accumulation therefrom of force.

(f) The focus was evidently a fissure, extending southeastwardly from Isla Zapatera in lake Nicaragua, for about 25 leagues into Costa Rica. J. CRAWFORD.

February 14, 1892.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Earth and Its Inhabitants. By ELISEE RECLUS. Vol. II, Mexico, Central America and West Indies. New York, D. Appleton & Co. 1891. 8vo, 504 pp, 227 illustrations, 40 plates and maps. This is a geographical description of Mexico, British Honduras, Central America, Panama, Gulf of Mexico and Caribean Sea, Cuba, Jamaica, San Domingo and Hayti, Puesto Ruo, Virgin Islands, The Bahamas, Bermudas and the Lesser Antilles. A statistical appendix of population and areas is also given. For the first time we have collected in a single volume a clear and concise statement of the geographic and economic conditions of the southern half of North America. The work is a mast rly treatise from the pen of a scientific authority, and presents more solid information concerning the orography, hypsometry, drainage, climate, floras, inhabitants, productivity and natural phenomena of the regions treated, than has hitherto been obtainable. The chapters on Mexico can be recommended as the most important reading to one who has a desire to become acquainted with that country.

"*Bosquejo de una Carta Geologica de la Republica Mexicana,*" compiled by a special commission, for the Secretary of Public Works, under the direction of PROFESSOR ANTONIO DEL CASTILLO, Director of the National School of Engineers.

This map is a grand contribution to North American Geology, and a credit to the fellow scientists of our sister republic. It is handsomely printed on heavy plate paper, upon the scale of $\frac{1}{3000000}$, and is so harmonious in color and void of irrelevant detail that its story is told with a plainness that is surprising, for here we have spread before our eyes the general features of Mexico, which every student of American areal geology has long desired to know. Three colors stand out in conspicuous boldness—yellow, green, and red—Quaternary, Cretaceous and eruptive, and these are the chief chapters of Mexican Geology—(1) A sedimentary floor of basal Cretaceous (Comanche) rocks—the continuation of our Texan features, but broken into mountain blocks and plateaux; (2) Great sheets of Quaternary sediments—the basin structure of Utah and Arizona, and the whole more or less covered by eruptive sheets. The Cretaceous is to Mexico what the Cambro-Silurian is to the United States - its fundamental sedimentary rocks, and this map shows the youthfulness of that region compared to ours, and the apparent migration southward of conditions, *i. e.*, the present basins, active volcanoes of southern Mexico similar to those of late Quaternary time in the southwest United States. The utter absence of paleozoic rocks is indeed most important food for reflection.

The critic might find cause for complaint in the absence of hypsometric data, but we must confess that in our opinion the chief virtue of the map is the omission of every possible line that would detract from its simplicity.

Bertrage zur Geologie und Paleontologie der Republik Mexico; von Dr. J. Felix und Dr. H. Lenke, (of Leipsig). Part i, Leipsig 1890. Part iii, Stuttgart 1891, 4to, with numerous plates and maps.

This work is the most important contribution to the geology of Mexico yet published, and by its excellent character and scientific composition immediately assures the reader of the ability and intelligence of its authors. Space forbids, however, the enumeration of all the valuable contents, which shed so much light upon North American geology.

Part i, after a preface explanatory of the lack of previous knowledge of Mexico, and an introductory sketch of its salient features, is devoted to the "volcanic chain of central Mexico, including descriptions of Tuxtla, Popocatapetl, Ajisco, Nevada de Toluca, Jorulla, the peak of Tancitaro, Colima, Orizaba, Cofre de Perote, Malinche, Iztaccihuatl, San Andreas Ceboruco and Tepie. It is impossible to enumerate here the numerous and important results given, but every line is a much desired contribution to knowledge, especially that concerning the glaciers of Popocatapetl.

Part ii is devoted to the valley of Mexico, and of itself is one of the most important contributions to the late Tertiary Geology of this continent. Several pages are devoted to a careful topographic sketch full of important data. Chapter 2 describes the remarkable Pleistocene deposits, showing a striking resemblance to the features of our own lake Bonneville as described by Gilbert. The earlier discoveries of a Pliocene vertebrate fauna by Cope are supplemented by new data. This fauna, consisting of Equus, Elephas, Mastodon Glyptodon, Bison, etc., is similar to that of the Fayette beds of Texas and the Equus beds of the great basin region.

The eruptive rocks of the valley were studied by Zirkel, and consist of amphibole andesites, hypersthene andesites of many kinds, and basalts. Finally a full table of altitudes is given.

Part ii contains two papers, the first by Drs. Felix and Lenke on the Geology of the State of Puebla, and the second by Dr. Felix on the Fossils of the Jurassic and Cretaceous formations of Mexico. In the part on Puebla the general geology is shown to consist of Cretaceous and Jurassic limestones, and the Pliocene Equus beds. Full notes are given on the fossil vertebrates of the latter formation. The Cretaceous is shown to consist of an upper horizon of limestones with Hippurites and Monopleura, which we believe analogous to the Monopleura and Caprina beds of the Glen Rose limestones of the Comanche series in Texas, while the lower division is very analogous to the Trinity formation of the same region. The remarkable superficial formation known in Mexico as tepetate is described—an incrustation of carbonate of lime deposited over the valleys by the streams from the limestone mountains.

The second part of Part ii contains accurate descriptions and beautiful plates of the Neocomian and Jurassic fossils of Puebla. If any one still doubts the existence of the marine Jura in North America an examination of these plates should convince him of his error.

The Geology and Paleontology of the Cretaceous Deposits of Mexico. By ANGELO HEILPRIN. (Proc. Phi. Acad Nat. Sci. 1890, extras, 1891.)

It is unfortunate while so much of value has been recently published concerning Mexico, that an American should contribute such a mass of error as is contained in this brief paper. Prof. Heilprin from a brief visit to southern Mexico, concludes that the great Neocomian and Jurassic formations so ably proven by Felix and Lenke are Upper Cretaceous, because they contain a hippurite fauna; as does the Upper Cretaceous of Europe. Although not much nearer Texas while in the City of Mexico than he was in Philadelphia, he devotes most of this paper to stating that assignment of the Comanche Series to the Lower Cretaceous by Prof. Hill is wrong, and that that great formation with its Neocomian fossils, its Wealdan reptiles and plants, its 4,000 feet of sediments stratigraphically below the Dakota sandstone of the Upper Cretaceous, all belongs to the latter formation. We can only refer Prof. Heilprin to the rocks, the fossils—plants, vertebrates and mollusca,—the writings of Marcou, Roemer, Hill and White, to assure him of the error of his conclusions.

Correlation Papers—Cretaceous. By C. A. WHITE. (Bulletin U. S. Geological Survey, Washington, 1891.) In this valuable compilation, many instructive pages are devoted to northern Mexico, especially concerning the development of the Comanche and Upper Cretaceous on the Rio Grande near Presudo del Norte, where the former rests on the Carboniferous—the only place in Mexico, so far as known, where the Carboniferous floor has been exposed. Interesting data are also given concerning the occurrence of the Laramie on the coastal slope near Lampazos. A valuable bibliography of publications on Mexican paleontology is given, to which we may now add "Preliminary Notes on the Topography and Geology of Northern Mexico," etc. By Robt. T. Hill, AMERICAN GEOLOGIST, September, 1891.

Official Maps of the Republic of Mexico, published by the Minister de Fomento. Thirty beautiful sheets of the Republic of Mexico illustrating the distribution of population, altitude, agriculture, soils, geology, railroads and mines, printed in a most artistic style, are a revelation to us of what our friends beyond the Rio Grande are doing for science.

In addition to these general maps there are several elegant contour maps of limited areas giving the topography of the vicinity of Mexico, the volcanic peaks of Popocatapetl and Ixahuapetl. These contour maps in artistic appearance are only slightly inferior to those issued by the leading surveys of Europe and America.

Part I, treating the political geography, describes the boundaries of the state, and gives an extensive table showing all the cantons, departments, municipalities and voting places, together with minute descriptions of the metes and bounds of the canton. A table is also given showing the population for the year 1885, and births and deaths. The total population of this small state was 1,159,341, and the births exceed the deaths by 7,257, showing the native civilization to be on the increase. The catalogue of settlements is quite extensive, and shows the existence of one capital (Guadalajara), 17 cities, 30 villages, 188 pueblos, 70 congregations, 387 haciendas, and 3,847 ranches

The chapters relating to geography, geology and botany are of chief interest however. The grand volcano of Coluna is described together with the other majestic peaks of this region. The valleys, canons and barancas, the basin plains, and every topographic feature are set forth clearly.

The tables of altitude are so comprehensive that a contour map could be easily constructed from the data given.

The third part, relating to geology, is of special interest. An excellent map is published. The oldest sedimentary rocks found are Cretaceous, while eruptive and other igneous rocks predominate. The Tertiary history of the basins is of chief interest, showing as they do that most of the so-called Plateau region of Mexico is but the southern development of our own great basin region, with all of its wonderful history of climatic changes and lacustral deposition.

Part VI is devoted to the flora, especially its relation to altitude. A lengthy table gives the scientific and popular names of all the plants, their economic uses, and the geological formations which they inhabit. This part alone is one of the most intelligible contributions to plant distribution ever published on this continent.

On the Clinton Iron Ore. C. H. SMYTH, JR. (Am. Jour. Sci., XLIII, 1892, pp. 487-496) Perhaps more illustrative facts, and more arguments to show the derivative origin of certain hematites from a change of limestone, have been drawn from the Clinton ore than from those of any other horizon. There seems to have been a widespread acceptance of that theory, at least for those ores, and the theory has been applied, perhaps without due circumspection to other formations. Pseudomorphous replacement of some carbonate, generally a limestone, but sometimes an iron carbonate, has been applied widely to explain the iron ores of the lake Superior region. More lately original oceanic deposition from chemical solution has been put forward for some of the lake Superior ores, on the ground that there is not sufficient evidence of the substitution theory. Now Mr. Smyth proposes to remove from the substitution hypothesis its original cause and key, and to place the Clinton hematites in the category of original chemical deposits of date coeval with the enclosing strata.

This result he bases on a careful and lengthy study of this ore at the typical locality, Clinton, N. Y., and in detail the steps of the proof are somewhat as follows:

1. The ore is not embraced in limestone, but in shales and sandstones, the latter so coarse sometimes as to be conglomerate.

2. The beds are nearly or quite horizontal, and not so placed as to allow easy and rapid access of ferriferous waters.

3. The ore is oolitic, and the oolyte has a concretionary structure, embracing in each lenticule, a rounded grain of quartz.

4. The concentric layers of the lenticules consist of alternations of silica and hematite, which becomes evident on the removal of the latter by hydrochloric acid. The silica is sometimes amorphous, and sometimes appears, under the microscope, to be chalcedony.

5. This structure pervades the Clinton ore from Dodge county, Wis., from Rochester and Ontario, N. Y., from Tennessee, Georgia and Alabama; and even when the ore consists largely of the forms of Bryozoa such forms are permeated and coated with layers of ore, associated with silica, showing an intimate relation in the origination of the silica and the ore.

6. The shoal waters indicated by the character of the associated rocks at Clinton, were favorable for the formation of iron ore by sedimentation.

7. If these lenticules were originally of calcite they must have been altered from the exterior inwardly, but in no case has there been found any remaining trace of such calcite.

8. The strata are still horizontal, and percolating waters could not so uniformly reach and change a limestone layer, and especially to the neglect of other limestones overlying, situated even more favorably for such change.

9. There seems to be a false chemical assumption in presuming that meteoric waters already surcharged with lime carbonate will also carry along iron salts and receive more lime in exchange for the iron at a certain definite stratigraphic level.

10. The lowest layer of iron ore is separated from that above it by a calcareous bed of shale. The substitution hypothesis requires that meteoric waters should pass through this shale leaving its 5 p. c. of lime unaffected and depositing no iron, but should abstract all of the lime in the lower layer where the ore is found—which seems to be gratuitous play of imagination.

11. The bottom tier contains a lean ore, but its leanness is not due to an excess of remaining lime, but to a greater deposit of concretionary and fragmental silica. "It is in fact a ferruginous sandstone."

12. Instead of a removal of calcite by percolating waters the process has been the reverse and calcite is found to embrace the iron spherules some of which have been partially broken and exfoliated prior to such calcareous deposition.

13. Wherever the spherules are found in patches and irregular groups throughout the rock, though not constituting a good ore, they are as completely formed of iron and silica as when they constitute ore. If they resulted from replacement they would naturally be only partially changed.

14. Oolitic iron ores are being formed at the present day in conditions similar to those supposed for the Clinton shores and estuaries; such only need dehydration, which goes on at ordinary temperatures, to resemble closely the Clinton ores.

The foregoing facts and considerations have led Mr. Smyth to the conclusion that the oolitic ores at Clinton are not of secondary origin but were deposited as hydrated peroxide of iron in intimate connection with cotemporary deposition of amorphous and chalcedonic silica.

"The Orthoceratidæ of the Trenton Limestone of the Winnipeg Basin." By J. F. WHITEAVES. (Transactions of the Royal Society of Canada, Vol. IX, Section 4, pp. 77-90. Plates V-XI, both inclusive. 1891—*distributed in 1892.*)

This is one of the most important contributions to the history of the Cephalopoda of the Ordovician rocks which has appeared for a long time. The paper consists, as the author indicates, "of a critical and systematic list of the *Orthoceratidæ* at present in the Museum of the Geological Survey of Canada from the formation and region indicated in its title, with descriptions of such species as appear to be new." In it Mr. Whiteaves considers the genera *Actinoceras* and *Sactoceras* as distinct from *Orthoceras* and *Poterioceras* from *Gomphoceras.*

The following table shows at a glance the species, author and references of each form in the paper in question.

Species.	Author.	Reference.
1. Endoceras annulatum, var.	Hall.	Plate V, figs. 1 and 1a, p. 77.
2. " subannulatum,	Whitfield.	" " " 2 and 2a, p. 78.
3. " crassisiphonatum,	N. Sp.	" VI, figs. 1-4, Pl. VII, fig. 1, p. 79.
4. Orthoceras simpsoni,	Billings.	" VII, figs. 2, 2a & 3, Pl. VIII, fig. 1, p. 80.
5. semiplanatum,	N. Sp.	" VIII, figs. 3 & 3a, p. 81.
6. " selkirkense,	N. Sp.	" VIII, figs. 2, 2a, 2b, p. 82.
7. " winnipegense,	N. Sp.	" VIII, figs. 4, 4a, 4b, p. 82.
8. Actinoceras richardsoni,	Stokes.	" IX, figs. 1, 2 and 3a, p. 83.
9. " bigsbyi,	Bronn.	" X, fig. 2, p. 84.
10. " allumettense,	Billings.	" X, figs. 3, 3a, p. 85.
11. Sactoceras canadense,	N. Sp.	" X, figs. 1a-c, p. 85.
12. Gonioceras lambii,	N. Sp.	" XI, figs. 1a-b, p. 86.
13. Poterioceras nobile,	Whiteaves.	Not figured, p. 87.
14. " apertum,	Whiteaves.	" XI, figs. 2 and 3, p. 87.
15. " gracile,	N. Sp.	" XI, figs. 4 and 4a, p. 87.

The specimens from which the above species are enumerated were collected for the most part by officers of the Geological Survey of Canada during their explorations and surveys in Manitoba and Keewatin: Messrs. Dr. Bell, Dr. Selwyn, Weston, Tyrrell, Dowling, Lambe, and also by Messrs. Donald, Gunn and McCharles from the same district. They form a valuable addition to the National Museum of Canada at Ottawa.

The Geological and Natural History Survey of Minnesota, Nineteenth annual report, for 1890. N. H. WINCHELL, State Geologist. 255 pages; with two plates, and 36 figures in the text. The first part of this report contains a translation of the treatise by Dr. Emanuel Boricky, "The Elements of a new Method of Chemico microscopic Analysis of Rocks and Minerals," 77 pages, with 40 figures of thin sections arranged on two plates. This work will be used in the study of the crystalline rocks of Minnesota, and will be welcomed by many petrographic students. Another translation presents a paper by the German geologist, Dr. J. H. Kloos, who made extensive observations in Minnesota before the beginning of the present survey.

The timber resources of Minnesota are discussed by Mr. H. B. Ayres, agent of the Forestry Division, U. S. Department of Agriculture. Though the average number of men employed in the state in preparing forest products for market reaches about 17,000, and the value of the annual product about $31,635,000, it is confidently affirmed that this industry and its supply need not soon decline, if the forest lands should receive legislative attention and proper care, as in some European countries.

Other divisions of this report comprise a valuable catalogue of the meteorites in the State University collection, with references to literature d-scribing them; notes on the petrography and geology of the Akeley lake region, in northeastern Minnesota, by W. S. Bayley; and descriptions of new Lower Silurian lamellibranchiata, chiefly from Minnesota rocks, by E. O. Ulrich, who describes and figures twenty-seven new species, referred to the genera *Tellinomya*, *Technophorus*, *Cleidophorus*, *Modiolopsis*, *Orthodesma*, *Cypricardites*, *Matheria*, *Ischyrodonta*, *Whitella*, *Cuneamya*, and a new genus named *Plethocardia*.

The principal Mississippian section. By CHARLES R. KEYES. Bulletin, G. S. A., vol. iii, pp. 283-300, with one plate; June 3, 1892. The term Mississippian is used, in accordance with the suggestions of Profs. Alexander Winchell and H. S. Williams, as a substitute for "Lower Carboniferous;" and the section here described in considerable detail, with careful correlations of the strata exposed at many localities, is seen in the bluffs of the Mississippi river from Burlington, Iowa, to Cape Girardeau, Missouri. The whole Mississippian series, as there observed, is divided into four groups, named in ascending order the Kinderhook, Osage, St. Louis, and Kaskaskia groups, which in turn comprise together fourteen recognized formations.

LIST OF RECENT PUBLICATIONS.

Papers in Scientific Journals.

The School of Mines Quarterly, Vol. XIII, No. 1, Nov. 1891, contains: The Filling of Mineral Veins, by J. F. Kemp.

The National Geographic Magazine, Vol. IV, contains: Studies of Muir Glacier, Alaska, by H. F. Reid.

The Canadian Record of Science, Vol. V, No. 1, contains: Additional Notes on Devonian Plants from Scotland, by D. P. Penhallow; On the Cherts and Dolomites of the Rocks of Thunder Bay, Lake Superior, by E. D. Ingall; Vol. V, No. 2, contains: Descriptions of some new Species of Fossils from the Cambro-Silurian Rocks of Quebec, by H. M. Ami; The Physical Features of the Environs of Kingston, Ont., and their History, by A. T. Drummond; Some Laurentian Rocks of the Thousand Islands, by Dr. A. P. Coleman; The Nickel Deposits of Scandinavia, by J. H. L. Vogt.

II. Proceedings of Scientific Societies.

Trans. Wis. Acad. Sci. Arts and Letters, Vol. VIII, 1888-1891, contains: Some Additional Evidences bearing on the Interval Between the Glacial Epochs, T. C. Chamberlin; On some Metamorphosed Eruptives in the Crystalline Rocks of Maryland, Wm. H. Hobbs; Notes on a little known Region of Northwestern Montana, G. E. Culver; On a new Occurrence of Olivine Diabase in Minnehaha County, South Dakota, G. E. Culver and Wm. H. Hobbs; Origin of the Iron Ores of the Lake Superior Region, C. R. Van Hise; On the Correlation of Moraines with Raised Beaches of Lake Erie, Frank Leverett.

Proc. Acad. Nat. Sci. Phil. (Jan. to Mar.) Remarks on the Quantity, Rate of Consumption, and Probable Duration of North American Coal, and the consequences to air-breathing animals of its entire combustion, Isaac J. Wistar; The development of the shell in the coiled stage of Baculites compressus Say, Amos P. Brown.

III. Papers in Scientific Journals.

Ottawa Naturalist, *May.* On Natural Phosphates. J. L. Willis. *June.* On the Sequence of Strata forming the Quebec group of Logan, with remarks on the fossil remains found therein. H. M. Ami. (Abstract.)

School of Mines Quarterly, *April.* Topographical Survey of New York State, W. P. Trowbridge; Analysis of Chromite, Walter and Vulte; Fossil Forests of the Yellowstone, W. H. Weed.

Nat. Geog. Mag., Vol. IV, contains: Studies of Muir Glacier, Alaska, Harry Fielding Reid; The Mother Maps of the United States, Henry Gannett; An Expedition through the Yukon District, C. Willard Hayes, (to page 163).

Geol. Mag. *April.* The Upper Trias of St. Cassian, Tyrol. Miss M. M. Ogilvie; On a new form of Discinocaris from Bohemia, Ottamar Novak; A new British phonolite, F. H. Hatch; Drift Coal in sandstone, G. W. Bulman; On the ash slates of the lake district, W. M. Hutchings; The age of the Himalayas, W. T. Blanford; Replies to various criticisms, J. F. Blake.

May No. On a Neuropterous insect from the Lower Lias, H. Woodward; The lamprophyres of the north of England, Alfred Harker; How to take impressions of fossils, J. G. Goodchild; On the origin of earthquake sounds, C. Davison; On the ash slates of the lake district, W. M. Hutchings.

June No. On the Devonian rocks of south Devon, A. R. Hunt; Permian in Devonshire, W. A. E. Ussher; The mammoth and the glacial drift, H. H. Howorth; On Ammonites jurensis, S. S. Buckman; The revised theory of glaciation, G. W. Bulman.

Am. Jour. Sci., *February No.* Bear River formation, a series of strata hitherto known as Bear River Laramie, C. A. White; Stratigraphic position of the Bear River formation, T. W. Stanton; Iron ores of the Marquette district of Michigan, C. R. Van Hise; Illustration of the flexibility of limestone, A. Winslow; Central Massachusetts moraine, R. S. Tarr; Proofs that the Holyoke and Deerfield Trap-sheets are contemporaneous flows, and not later intrusions, B. K. Emerson.

March No. Mt. St. Elias and its glaciers, I. C. Russell; Hudson River fiord, A. M. Edwards; Contributions to mineralogy, No. 52, F. A. Genth; Tschermak's theory of the chlorite group and its alternative, F. W. Clarke; Recent fossils near Boston, W. Upham; The highest old shore line on Mackinac Island, B. F. Taylor; Observations upon the structural relations of the upper Huronian, lower Huronian and basement complex on the north shore of lake Huron, R. Pumpelly and C. R. Van Hise; Preliminary report on observations at the deep well at Wheeling, West Virginia, W. Hallock; Mount Bob, Mount Ida or Snake Hill, T. W. Harris; Discovery of Cretaceous Mammalia, O. C. Marsh.

April No. Melilite-bearing rock (Alonite) from St. Anne de Bellevue near Montreal, Canada, F. D. Adams; Azure-blue pyroxenic rock from the Middle Gila, New Mexico, G. P. Merrill and R. L. Packard; Correlation of moraines with raised beaches of lake Erie, F. Leverett; Plicated cleavage-foliation, T. N. Dale; Geological age of the Saganaga syenite, A. R. C. Selwyn; Third occurrence of peridolyte in central New York, C. H. Smyth, Jr.; Fulgurite from Waterville, Maine, W. S. Bayley; Mineralogical notes on brookite, octahedrite, quartz and ruby, G. F. Kunz; Recent polydactyle horses, O. C. Marsh.

May No. Experiments upon the constitution of certain micas and chlorites, F. W. Clarke and E. A. Scheider; The age and origin of the Lafayette formation, E. W. Hilgard; Plattnerite and its occurrence near Mullan, Idaho, W. S. Yeates, with crystallographic notes by E. F. Ayres; Upper silurian strata near Penobscot bay, Maine, W. W. Dodge and C. E. Beecher; A meteorite from Pennsylvania, W. G. Owens; Two meteoric irons, G. F. Kunz and E. Weinschenk; A new order of extinct Eocene mammals (*Mesodactyla*), O. C. Marsh; Notice of new reptiles from the Laramie formation, O. C. Marsh.

June No. Sub-divisions in Archean history, J. D. Dana; Clinton iron ore, C. H. Smyth, Jr.; Josephinite, a new nickle-iron, W. H. Melville; Fibrous intergrowth of augite and plagioclase, resembling a reaction rim, in a Minnesota gabbro, W. S. Bayley; Notes on Triassic Dinosauria, O. C. Marsh.

July No. Polybasite and tennantite from the Mollie Gibson mine in Aspen, Col., S. L. Penfield and S. R. Pearce; Post-Laramie deposits of Colorado, W. Cross; Fossils in the Archean rocks of central Piedmont, Va., N. H. Darton; Notes on the Cambrian rocks of Virginia and the southern Appalachians, C. D. Walcott; Synthesis of the minerals crocoite and phœnicochroite, C. Ludeking; A hint with respect to the origin of terraces in glaciated regions, R. S. Tarr; Occurrence of a quartz boulder in the Sharon coal of northeastern Ohio, E. Orton.

IV. Excerpts and Individual Publications.

Gordon's Specimen Record. C. H. Gordon, Evanston, Ill.

Clays of the Hudson River Valley. H. Ries. Trans. N. Y. Acad. Sci., Vol. XI, p 33, 1891.

The Geological Map of the United States and the United States Geological Survey. Jules Marcou, Cambridge, 4to, 56 pp., 1892.

A Review of Artesian Horizons, in southern New Jersey. Lewis Woolman. From the An. Rep., State Geologist, 1891.

A Study in Geology. E. C. Quereau, [a general description of the Alps.] From the report for 1891 of the Dept. of Nat. Hist. Northwestern University, Evanston.

On a New Variety of Gaylussite from San Bernardino County. Henry G. Hanks. From Mining and Scientific Press, Mar. 26, 1892.

Note on Leptoplastus. G. F. Matthew. Can. Rec. of Sci., Dec., 1891.

List of Fossils Found in the Cambrian Rocks in, or near, St. John, N. B. G. F. Matthew. Bul. Nat. Hist. Soc. No. x.

Rules of Nomenclature Adopted by the International Zoölogical Congress, Paris, 1889. Translated by Moritz Fischer. Am. Nat., May, 1892.

The Paleontology of the Cretaceous Formation on Staten Island. Arthur Hollick. Trans. N. Y. Acad. Sci., Vol. IX, No. 5, 1892.

Albirupean Studies. P. R. Uhler, Maryland Acad. Sci., 1892, pp. 185-200.

On the Ore Deposits of Newman Hill, near Rico, Colorado. John B. Farish. Proc. Col. Sci. Soc., Apr. 4, 1892.

The Terminal Moraine of the Continental Ice-sheet, and the Ice-age. Frank W. Very, Acad. Sci. Art, Pittsburgh, Oct., 1891.

Suggestions for the Preparation of Manuscript and Illustrations for Publication by the U. S. Geological Survey. W. A. Croffut.

Elæolite syenite near Beemerville, Sussex county, N. J. J. F. Kemp. Trans. N. Y. Acad. Sci., Vol. IX, p. 60, 1892.

Illustrations of the Fauna of the St John Group, No. VI. G. F. Matthew. Trans. Roy. Soc. Canada. 4to, 32 pp., 2 plates, 1891.

Three Deep Wells in Manitoba, J. B. Tyrrell. Trans. Roy. Soc. Canada, 4to, 14 pp., 1891.

V. Foreign Publications.

Mineralogy, F. H. Hatch, small 12mo., 123 pp. London, Whittaker & Co.

A typical section, taken in detail, of the "Main coal" of the Moira, or western division of the Leicestershire and South Derbyshire coalfield, W. S. Gresley, Trans. Man. Geol. Soc., Part XVII, Vol. XXI.

On the Glacial period, and the earth movement hypothesis, James Geikie. Read before the Victoria Institute, London; Supposed causes of the Glacial Period, (Edin. Geol. Soc. 18 Nov., 1891,) James Geikie.

Trans. Edin. Geol. Soc. Sess. 1890-1891, contains: Landscape Geology; a plea for the study of geology by landscape painters, Hugh Miller; The southwest Mayo and northwest Galway silurian basin, with notes on the old or metamorphosed rocks of West Galway, G. H. Kinahan; Obituary notice of James Croll, J. Horne; An outlier or minor basin of Old Red sandstone, in Mid-Ross-shire, Wm. Morrison; The occurrence of plant remains in olivine basalt in the Bo'ness coalfield, Henry M. Cadell; On the more notable Scottish earthquakes which have occurred during the present century, Ralph Richardson; Homacanthus borealis *Traq*, a new selachian from the Lower Old Red of Caithness, W. T. Kinnear; Supposed causes of the glacial period, James Geikie.

Records of the Geological Survey of New South Wales, Vol. II, part 4, 1892, contains: On the general geology of the south coast, with petrological notes on the intrusive granites and their associated rocks around moruya, Mount Dromedary and Cobargo, Wm. Anderson; Descriptions of four Madreporaria rugosa species of the genera Phillipsastræa, Heleophyllum, and Cyathophyllum, R. Etheridge; The cave shelters near Wollombi, in the Hunter river district, P. T. Hammond.

Notice biographique sur Gustave Maillard, E. Renevier [Tiré du Bull. Soc. Vand. Se. Nat. XXVIII, No. 106].

Bul. de la Soc. des Naturalistes de l'ouest de la France, *Tome I, No. 4* contains: Description des gneiss à pyroxene de Bretagne, et des cipolins qui leur sont associés, A. La Croix; Terrain metamorphique et chimique de la ville-au-Vay, pres le Pellerin, avec liste de roches et des mineraux que l'on y vencontre, Ch. Baret.

Annales de la Soc. Geol. de Belgique, Tome XVIII, 1ve Liv., contains: Note sur les rapports des etages Tournaisien et Viseen de M. Dupont, avec son etage Waulsortien, C. de Vallee Poussin; Quelques particularites remarquables de la planchette de Herve, H. Forir; Etudes sur l' Assise de Rouillon X. Stainier; Le Poudingue de Naninne à Strud et à Dave, X. Stainier; Les Failles des Samson, X. Stainier; Le Terrain honiller à Salzinne-les-Moulins, X Stainier; Le Gres blanc de Maezeroul, X. Stainier; Sur les notations compliquées des cristaux de calcite, G. Cesaro; Sur un terme nouveau du Quarternaire inférieur observé en Belgique, E. Delvaux; Etudes stratigraphique et paleontologique du Sous-sol de la Campine, E. Delvaux; Sur la significance des conglomerats à Noyaux Schisteux des Psammites du Condroz, Max Lohest; Les terrains Tertiaires superieurs du basin de la Mediterranée, Chas. de Stafani.

Tome XIX, Liv. I, contains: Sur un facies remarquable de l' Assise de Herve, H. Forir; Etude sur les limons herbayens et les temps Quaternaires en Belgique, Alp. Briart; Description stratigraphique et paleontologique d' une Assise de sables, inferieurs à l' argile ypresienne, representant in Belgique les *Old Havens beds* du bassin de Londres, E. Delvaux.

Eclogæ geologicæ Helvetiæ, Avril, 1892, contains: Note sur les cornieules du Pays-d' Enhaut, T. Rittener; Notice sur un affleurement d' Aquitanien dans le Jura Vaudois, T. Rittener; Pleistocene du Nord de la Swisse et des parties limitrophes du Grand-Duche de Bade, G. Steinman et L. du Pasquier; Etude stratigraphique sur les terrains Tertiaires du Jura Bernoes, L. Rollier.

Foldlani Kozlony, March-April, 1892, contains: Dr. Carl Hofmann (with portrait), L. Roth v. Telegd; Ueber den grossen Freigoldfund aus der Umgebung von Brád, Aug. Franzenau.

Bull. Soc. imp. Naturalistes de Moscou, No. 2 and 3, 1892. contains: Argiles de Speeton et leurs equivalents, A. Pavlow and G. W. Lamplugh; Qu' est ce que c' est que l'Hipparion, Marie Pavlow.

Mittheilungen über das Glacialgebiet Nordamerikas; Die endmoränen, Felix Wahnschaffe, [ab. Zeitschr. deut. geol. Gesell, 1892].

Ursachen der Deformationen und der Gebirgsbildung. Ed. Reyer, Leipzig, 1892.

Ueber den gegenwärtigen Standpunkt unserer Kentniss von dem vorkommen Fossiler Glacialpflanzen, A. G. Nathorst. [Bihang Svens. vet akadhandl. Bd 17, A'd III No. 5].

Die Nordamerikanischen Wüsten, J. Walther, [Verhand. Gesell. f. Erdkunde zu Berlin, XIX, 1892, No. 1].

VI. Laboratories and Museums.

Bul. Lab. of Nat. Hist. State Univ. of Iowa, Vol. II, No. 2, contains: Report on some fossils collected in the Northwest Territory, Canada, by Naturalists from the University of Iowa, S. Calvin; Two unique spirifers from the Devonian strata of Iowa, S. Calvin; A geological reconnoissance in Buchanan County, Iowa, S. Calvin; Notes on a collection of fossils from the Lower Magnesian limestone from northeastern Iowa, S. Calvin.

CORRESPONDENCE.

Two or three years since, I concluded to find out, if I could, the character of the termination of the column of the crinoid Heterocrinus subcrassus, having a Lower Silurian slab showing about one hundred specimens of the calyx, and columns in a great profusion.

I selected a column attached to its calyx, and followed it by uncovering, until I was rewarded by discovering the column diverging into well defined roots:—length of column from calyx 12½ inches.

At that time I believed that the genus Glyptocrinus were floaters, and devoid of bases or roots.

About eighteen months ago, something caused me to doubt that idea, and I commenced the investigation of the t-rmination of their columns, and now, after a great deal of work, and after many discouragements, I have been able to so far develop roots on the terminations of the columns of Glyptocrinus neali, Glypt. dyeri, and Glypt. baeri. I have a specimen of each species, showing the calyx, column, and roots intact, and one slab of Glypt. baeri having on its surface several specimens of that character.

One character of the specimens surprised me:—the diversity in the length of the columns between calyx and roots in the specimens just mentioned. In Glypt. neali the length varies from two to four or five inches, Glypt. baeri from one-half inch to six or eight, and in Glypt. dyeri from one to four or five inches.

I have also found a specimen of Heterocrinus simplex, showing calyx, column, and inverted saucer-like base, attached to another column.

For further information in regard to above, address,

DR. D. T. D. DYCHE.

Lebanon, Ohio, July 22, 1892.

GLACIAL STRIÆ IN KANSAS. I have just measured (July 8, 1892) the direction of undoubted glacial striæ in northern Kansas. The striated rock is a limestone covered with a stiff boulder-clay. The boulders are largely red quartzite, syenite, diorite, slate, and porphyry, the first predominating.

A fair moraine crosses the southern part of Nemaha county, where the drift is over 100 feet thick. Some of the deeper wells pass through a forest bed at the depth of 80 feet. Sticks and carbonaceous earth are brought up from about that depth in several localities.

The striæ run to the south, southwestward. More exactly they run in: Quarry No 1, Tn. 3, S., Sec. 17, R. 12, E., S. 24°, 36′ W. Quarry No. 2, 30 rods south of No. 1, S. 21 , 08′ W., both corrected for magnetic declination.

I think that I am right in saying that these are the only striæ that were formed during the first glacial epoch that have thus far been discovered in this state. Large slabs of the striated limestone have been taken from quarries in Nemaha county, and very many of the drift boulders are likewise beautifully grooved. L. C. WOOSTER.

Eureka, Kansas, July 8, 1892.

IN THE TEXAS PANHANDLE. I have had a ride on a gray stallion of 250 miles (from Big Spring, on the Texas Pacific railroad, almost due south of here) and am much the better for it in health. We have had all kinds of weather except rain, and this is a dry season even for this dry country. The weather has been alternately cold and hot, often presenting a difference between day and night of thirty to forty degrees. Wind is almost constant, sometimes amounting to a gale or more, and the tendency is of course to keep us cool—sometimes too cool—when the wind has been from the north. On the other hand a temperature of 90°-100° Fah. does not feel hotter here than 75°-80° in Philadelphia. Our greatest difficulty has been bad water; in the last 60 miles before reaching here we had only one decent spring, and we had to dig to get that free from the pollution of cattle. The other waters were either rain-holes or strongly alkaline.

Our party is in charge of W. F. Cummins of the state survey. Scientifically we have had a successful trip. Our line has been along the eastern escarpment of the staked plains, with an occasional excursion on the plains and across its spurs. We have accessible Permian, Trias, Loup Fork, and Blanco beds. Lower down the country we had Cretaceous-marine; all the beds here are lacustrine or estuary. The Blanco beds are above the Loup Fork, and contain a new vertebrate fauna, mostly mammals. We have so far fourteen species, of which ten are new to science, two of of them mastodons. The Loup Fork beds we have just discovered here, and the fossils are very numerous. We found a grave-yard of horses (three species), camels (two species) and mastodons (one or two species). The ground was covered for acres with their bones, and in the bank we got out in a few hours six nearly perfect skulls—all horses. So far no Carnixora, but we shall get them. The absence of rhinoceros is so far peculiar, but we shall get them I suppose. We got none in the Blanco beds. This formation forms the entire surface of the *Llano estacado* and is underlain by Trias and Permian. We found only the Loup Fork here, and how far it passes under the plains we have yet to know. EDW. D. COPE.

Clarendon, Texas, June 13, 1892.

DR. WAHNSCHAFFE'S WORK ON THE DRIFT DEPOSITS OF GERMANY.—I was much interested in reading professor Salisbury's review of the "Drifts of the North German Lowland," in the May number of the AMERICAN GEOLOGIST. It was gratifying to find one German geologist, at least, who seemed to favor the aqueous origin of kettle-holes.

In 1885 the writer published a small pamphlet on the drift formations of Long Island, in which the theory was advanced that the depressions connected with the terminal moraine were the result of sub-glacial streams. About this time, the late H. Carville Lewis had published a paper on "Marginal Kames," and in it, he maintained that kettle-holes were not the result of natural erosion, and that they were in no way allied to ordinary valleys. I was confident, however, that future investigation would prove that he was in error, although I knew him to be a very close observer. It seems that their origin is still a disputed question.

Professor Wright, in his recent work, the "Ice Age in North America," adopts the view that their formation was due to dirt bands formed on the ice, although on page 54 he gives a picture of the Muir glacier where kettle-holes are in process of formation seemingly by the action of sub-glacial streams.

I called his attention to this fact, and he admitted that in some cases kettle-holes owed their origin to sub-glacial streams.

It seems from the review of Dr. Wahnschaffe's work referred to, that only one geologist—E. Geinitz—attributes them chiefly to the eddying action of waters during the melting of the ice. Dr. Wahnschaffe and others do not seem to favor this view, but insist that the waters arising from the melting of the last ice-sheet had no considerable influence in their formation. He argues that the depressions were already in existence at the time of the deposition of the uppermost layer of till, which is doubtless true, but this need not weigh against their sub-glacial stream origin; as the channels may have been dried up, to some extent at least, before the final retreat of the glacier. The depressions in question are no chance formations but belong to a beautiful and wonderful system of glacial drainage. They are in reality sub-glacial valleys—the meeting place of the waters under the ice-sheet. Professor H. Carville Lewis argued that the rim of the basins was too perfect to admit of this, but when closely examined it will be found that the rim is generally more or less indented. The basin, of course, corresponds to the size of the streams that came together under the glacier. The small streams make the most perfect kettle-hole, while the larger rivers form the large ponds, swamps and peat-beds. I have studied this phenomenon for years along the whole extent of the terminal moraine on Long Island, and the longer I study the more I am convinced that these depressions are in some way related to sub-glacial or super-glacial drainage.

The "ground moraine landscape" (= our terminal moraine) and the hills and ridges of sand and gravel, the German *Durchragungszuge und käme*, owe their modification to these glacial rivers, and I believe with professor Salisbury that they are closely associated in time of origin.

I cannot think that pressure has had much to do with the formation of these moraine ridges on Long Island, as the material does not appear to be *bulged up* as intimated by Dr. Wahnschaffe, although there are a few writers who think they see evidence of pressure, and attribute the formation of some of the kame moraines, on the north side of the island, to lateral thrust. I cannot think so.

It seems as if the *debris* had been carried along with, and in the ice-sheet, and as it fell from the grasp of the glacier much of it was assorted over by sub-glacial currents, and washed out from its terminal front, forming what is known as the south side of Long Island ("overwash plains, whose surfaces show little relief"), yet the streams that issued from the front of the ice-sheet can be traced from the terminal moraine to the sea, and in places there are some conspicuous ridges which seem to run under the ocean, for Prof. Agassiz writing to Elie De Beaumont says, "the submarine dykes along our coast would be osars if they were elevated." These professor Wright calls kame deltas while the hummocky ridges connected with our terminal moraine the late H. Carville Lewis would designate "marginal kames." These marginal kames are always more prominent where the flood of waters was greatest, and are pushed further to the south, as may be seen near Fort Hamilton. Where the streams were not so powerful, the "ground moraine landscape," our terminal moraine, ends more abruptly and the kettle-holes are more complete. Where the waters broke through, as at Hempstead, the terminal moraine disappears, and the plain becomes more extensive, and Far Rockaway point is the result.

There is a slight difference of nomenclature among the glacialists of Europe and America, but the phenomena seem very much the same. I have never observed on Long Island anything that seems to answer to the Endmoräne of the Germans, nor such dykes as G. H. Kinahan describes as occurring in the counties of Wexford and Carlow, Ireland, and yet, in my last letter to the GEOLOGIST on Englacial Drifts, I spoke of a section in the Rockaway Railroad cut that would seem to combine the three sets of phenomena mentioned in the review of Dr. Wahnschaffe's work, the *Grundmoranenlandschaft*, the *Endmoräne* and *Durchragungszuge und Käme*. I said: "In the center of the bottom part of the drift is a mass of boulders in a sandy matrix, and over this is the hardpan, which is also full of erratics. Then comes the modified drift, and over all the englacial till which was probably laid down after the floods had subsided."

Thus we see that the same conclusions are being reached by independent investigation. JOHN BRYSON.

Eastport, L. I., July 6, 1892.

PERSONAL AND SCIENTIFIC NEWS.

THE GEOLOGICAL SOCIETY OF AMERICA meets in Rochester, N. Y., August 15 and 16, in conjunction with the American Association for the Advancement of Science. A joint letter from the Royal Society of Canada, and from the "Logan Club" at Ottawa, has been addressed to the president and secretary of the Geological Society of America, inviting them to meet next December, in Ottawa, the Canadian capital. Ottawa is the leading scientific centre in Canada now, and the fact that the Geological Survey staff and museum are there will be sufficient earnest of the likelihood of an enjoyable as well as of a profitable meeting. Several fellows have already expressed their willingness and desire to attend, and are in favor of Ottawa. The matter will come up for consideration before the Council of the Society at Rochester.

PRESIDENT CHAMBERLIN, of the Wisconsin State University, has accepted the professorship of geology in Chicago University.

DR. CHARLES E. BEECHER HAS BEEN APPOINTED assistant professor of paleontology at Yale University, New Haven.

MR. L. V. PIRSSON, who has been studying the past two years in Heidelberg and Paris, will teach petrography at Yale University during the coming year.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, under the presidency of Prof. Jos. Le Conte, will meet at Rochester, N. Y., August 16. Provision has been made by the local committees for entertainment and numerous excursions.

M. ALP. BRIART IN A RECENT REVIEW of the "Limons hesbayens" in Belgium, arrives at the conclusion that they are separable into two parts (at least) and that between them occurred an interglacial epoch of great length. This interglacial epoch he pronounces the "veritable *époque quaternaire*," the ice incursions themselves being only episodes.

The Geological Commission named by the law creating a Geological Survey for Iowa met on the 8th of July for the purpose of appointing a State Geologist. After considering the claims and recommendations of the various applicants they unanimously elected Prof. S. Calvin of the State University, notwithstanding the fact that he was not an applicant and had been doing all in his power to secure the election of another.

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DESCRIPTION OF TWO NEW GENERA AND EIGHT SPECIES OF CAMERATE CRINOIDS FROM THE NIAGARA GROUP.*

By CHARLES WACHSMUTH and FRANK SPRINGER, Burlington, Iowa.

IDIOCRINUS W. and Sp. (nov. gen.)

(ΙΔΙΟΣ peculiar, ΚΡΙΝΟΝ a lily.)

Infrabasals apparently 5, extremely small; placed at the bottom of a more or less deep concavity, and completely hidden by the column. Basals 5, very large; the posterior one truncated by the interbrachio-anal plate. Radials very large; four of them heptagonal; the two adjoining the anal side hexagonal. Costals 2, almost linear and considerably narrower than the radials; the first quadrangular, and three or four times as wide as high; the second pentangular, the sides of its upper angle almost straight. Distichals 2 in the calyx; short. Interradial area on all sides composed of a single, large plate, which rises to the top of the dorsal cup. That of the anal side resting upon the basals, the four others upon the sloping upper faces of the radials. Ventral disk quite variable in form; covered by a large, undivided oral pyramid. The ambulacra tegminal, and in the typical species lined by small side-plates. Interambulacrals rep

*The species will be finely illustrated in our forthcoming Monograph on the Crinoidea Camerata of North America.

resented by only one large, subtrigonal piece. Anus excentric. Structure of arms and column not known.

Type: Idiocrinus elongatus.

Distribution: So far as known, restricted to the Niagara group of America.

Remarks. Differing from all other dicyclic Camerata in having a single plate in the anal area, in its central, undivided oral pyramid, and in having but one interambulacral plate to each side of the disk.

IDIOCRINUS ELONGATUS W. and Sp. (nov. spec.)

A small species. Calyx obconical; the ventral disk on a level with, or below, the upper margins of the dorsal cup; the cup deeply excavated at the bottom, the basals forming a large funnel-shaped pit. Plates without ornamentation and flat, except the radials, which are a little convex, and rise slightly above the plane of the cup. Suture lines not grooved.

Infrabasals minute, constituting the bottom of the basal concavity. Basals extremely large and elongate, the lower end curving abruptly inward, and forming a sharp edge around the bottom of the calyx; the exposed part of the plates rising to more than one-third the length of the dorsal cup. Radials once and a half as wide as high, distinctly angular at their lower faces; the two posterior plates hexagonal, being truncated by the interbrachio-anal plate. Costals together less than half the size of the radials; the first linear; the second a very little higher, and its upper angles quite obtuse. Distichals 2, somewhat higher and wider than the costals; the upper semi-free. Interbrachials one, those of the four regular sides resting upon the deeply sloping sides of the radials, the anal one upon the narrowly truncated basal; all extending to the upper end of the calyx, and all much higher than wide.

The oral pyramid is somewhat weathered in the type, and the median part is imperfect, the apparent opening in the center being a mere break. The specimen, however, is interesting as showing indistinct traces of inter-oral sutures, which are obsolete in other specimens of this genus. The pyramid occupies nearly one-third the width of the disk, and its upper end, when perfect, formed a level with the distal faces of the second distichals. Interambulacral plates one, forming a triangular area lined by small side-pieces, which stand erect and form upon the surface well-defined open grooves, of which the covering-pieces were not preserved. These grooves, as they pass out from the orals, bend at first slightly downward, but after bifurcating proceed upwards to the arms. Nothing is known of the structure of arms and column.

Horizon and Locality: Upper part of Niagara group; St. Paul, Shelby Co., Ind.

Type in the collection of Wachsmuth and Springer.

IDIOCRINUS VENTRICOSUS W. and Sp. (nov. spec.)

A very small species. Calyx nearly as wide as high; hight of dorsal cup about equal to that of the tegmen; the former bowl-shaped, the cup obtusely pyramidal. Plates smooth; the radials and costals somewhat longitudinally convex, causing a depression of the interbrachial spaces. Suture lines slightly grooved.

Infrabasals extremely small and covered completely by the column; placed at the bottom of a narrow circular cavity, formed by the lower ends of the basals. Basals of moderate size, their lower ends incurving and forming the sides of the concavity, their upper angles slightly bending upwards. Radials once and a half as large as the two costals together, and twice as wide as high; three of them heptagonal, the two posterior ones hexagonal. First costals quadrangular, much narrower than the radials, and three times as wide as high; the second of nearly the same width as the first but longer. Distichals narrower and shorter than the second costals. Interbrachials large, subelliptical; that of the anal side a little wider, and truncating slightly the posterior basal. Oral pyramid convex, a very little tumid, extremely large for the size of the species, perfectly closed at the summit, and the interoral sutures obsolete. The outer face of the pyramid is covered with well defined radiating ridges, which proceed from the middle of the plate to the outer margins, increasing in hight and width as they pass outward. Ten of these ridges are more prominent, and project outward around the circumference, so as to give to the plate the aspect of a ten-rayed star. The inner floor is excavated centrally, and there are five deep grooves passing out in a radial direction. The interambulacral plates long, slender and cuneate, attached with their narrower upper ends to the inner margin of the orals. They project outward so as to form at their sides open spaces for the reception of the ambulacra. Other parts unknown.

Horizon and Locality: Upper part of Niagara group; near St Paul, Ind.

Type in the collection of Wachsmuth and Springer.

Remarks. The oral pyramid of this species, which is found occasionally detached from the body, was regarded by Miller, Benedict and ourselves to represent probably the ventral structure of some *Pisocrinus*. This appeared the more plausible as it was expected from analogy that in *Pisocrinus*, as in the allied *Symbathocrinus* and *Haplocrinus*, the ventral disk consisted of orals only, and the plate fitted approximately upon the cup of one of the species, which occurs in the same bed.

HYPTIOCRINUS W. and Sp. (nov. gen.)

(ΥΠΤΙΟΣ bending back, ΚΡΙΝΟΝ a lily.)

Name applying to the character of the arms which hang downward. Calyx depressed, wheel-shaped. Infrabasals 5, small. Basals 5, four of them equal, angular at the upper end; the posterior one truncated by the anal plate. Radials comparatively small, all hexagonal. Costals 2. Fixed brachials rather large, except the first costals, which are quite short and quadrangular. First distichals one, the distal face broadly truncated; followed by several sharply cuneate pieces, which interlock, and of which the two or three proximal ones (in the type) take part in the calyx. Arms stout, probably biserial, and pendent, to judge from the arm openings, which are directed obliquely downward. First interbrachials of the regular sides very large; succeeded by several rows of smaller pieces. Anal plate touching the basals, and higher than the radials; supporting three much smaller plates in the next row, and others above. Ventral disk depressed; the posterior oral and the radial dome plates spinous; the anus excentric, and at the top of a large protuberance.

Distribution: So far as known, restricted to the Niagara group of Indiana.

Remarks. The genus has its closest relations with *Thysanocrinus*, from which it differs in the flatness of the calyx, in the pendent arms, and in the spine-bearing disk.

HYPTIOCRINUS TYPUS W. and Sp. (nov. spec.)

Specimens of medium size. Calyx wheel-shaped, nearly once and a half as wide as high. Dorsal cup broadly obconical to the top of the costals, then flanging outward and somewhat downward. Arm regions not lobed, but the upper margins of the interradial and interdistichal spaces formed into sharp edges by means of corresponding depressions in the dorsal cup and tegmen. Costals and distichals marked by rounded, longitudinal ridges, following the median line of the plates. Ventral disk a little higher than the dorsal cup, its lateral margins slightly bulging, the lower end somewhat projecting over the upper margin of the dorsal cup. The plates flat, their surfaces in well preserved specimens densely covered by fine granules.

Infrabasals small, hidden by the column; forming a flat, pentagonal disk. Basals rather large, about as wide as high, curving abruptly upwards; the posterior one slightly truncated at the upper end; the interbasal suture lines distinctly grooved. Radials twice as wide as high, their proximal ends distinctly angular. First costals much shorter and narrower than the radials, quadrangular. Second costals higher and a little wider than the first; their lateral faces short; the sloping upper faces placed at right angles. First distichals as large as the axillary costals, followed by two or three cuneate plates in the calyx, which slightly interlock. Structure of the arms not observed, but they were undoubtedly biserial and pendent. First interbrachials of the regular sides the largest plates of the calyx; they reach up to the sides of the first distichals and are succeeded by two rows of two plates each. The anal plate a little higher than the radials, supporting three, two and two smaller plates. Interdistichals one, small. Posterior oral nearly central, large and extended into a heavy, short spine; the four other orals proportionally small and almost flat. Radial dome plates represented by plates of a first and second order, those of the latter by two or three plates to each division, alternately arranged; all large and spine-bearing. The spines near the outer margins of the disk directed obliquely outward, and visible in a dorsal aspect of the calyx. Interambulacral plates numerous, of the size of the smaller orals, and irregularly arranged. Anus excentric, placed at the top of a large ovate protuberance, which rises conspicuously above the general plane of the disk.

Horizon and Locality: Niagara group; St. Paul, Shelby Co., Indiana.

Type in the collection of Wachsmuth and Springer.

Eucalyptocrinus lindahli W. and Sp. (nov. spec.)

Above medium size. Most remarkable for its heavy, rounded arms, which to their full length are elevated prominently above the outer faces of the partition walls, so the latter are forming the bottom of a deep groove. Dorsal cup semi-globose, its lower concavity not larger than the width of the stem, and enclosing only the basals, which are hidden from view by the narrow, round stem. Plates not distinctly ornamented, merely showing a roughened surface. Suture lines slightly grooved.

Radials rather large, as high as wide, rapidly sloping to the lower end; their lateral faces three times as long as the slanting upper; the superior face concave. First costals quadrangular, smaller than the radials, a little wider than high. Second costals hexangular, wider and higher than the first; their sloping upper faces longer than any of the others; the upper angle slightly truncated by the interdistichal. First distichal smaller than the axillary costal, the second less than half the size of the first and subquadrangular. Palmars three in the calyx, transversely arranged, rounded on the back. First interbrachials ten-sided, as large as the radials, longer than wide, widest at the middle; the two of the second row nearly three times as long as wide, rising to the hight of the third palmars. The interdistichal a little shorter and narrower than the two upper interbrachials combined. The walls forming the compartments taper gradually to near the upper end, then widening rapidly and curving abruptly inward, so as to form a flat surface at the summit on a level with the tips of the arms. Arms rather short, very heavy, almost cylindrical. They rise above the sides of the partitions much more conspicuously than is known to be the case in any other species, their tips being lifted out from between them almost completely.

Horizon and Locality: Niagara group, Wayne Co., Tenn.

Type in the Illinois State Museum. The species is named in honor of Dr. Josua Lindahl, the eminent zoölogist and director of the state museum at Springfield.

CALLICRINUS BEACHLERI W. and Sp. (nov. spec.)

Closely resembling *Eucalyptocrinus.* The calyx has the form of a wine bottle, with long slender neck and a deep concavity at the bottom, but the partition walls, instead of forming closed compartments to the full length of the arms, rise only to a certain hight, and are not closed from above. Hight of the calyx to the base of the tubular neck one-fourth greater than the width at the top of the dorsal cup; the hight of the cup 11 millim., that of the ventral disk 16 millim., and the length of the partition walls 8 millim. Dorsal cup broadly truncated at the base; the sides almost straight, gradually expanding upwards. The radials and costals at their surfaces sharply keel-shaped, especially the former, and the angularity continued upon the distichals, but not attaining the prominence as on the plates below; the first interbrachials slightly convex, with a small tubercle in the center.

Basals small and nearly of the same size, forming a concavity, which is rather small and shallow for the genus. Radials near the upper end fully as wide as long, and twice as wide as at the lower part, which curves gently inward to meet the basals. First costals twice as wide as high; the second, which is higher and wider, rarely truncated by the interdistichals. First distichals twice as large as the second, and but little smaller than the axillary costals. The palmars small and pentangular. First interbrachials longer than wide, a little smaller than the radials; the upper two together nearly twice as wide as the first, their upper ends rising to the hight of the second or third arm plates. Interdistichals but little smaller than the upper interbrachials, and protruding upwards in a similar manner. Ventral disk conical, its sides convex. The ten plates which rest upon the interbrachials and interdistichals, respectively, and form the compartments for the reception of a pair of arms, are twice as high as the intervening ones, which rest against the sloping upper faces of the palmars. There are in all twenty partitions around the disk, and each arm occupies a separate compartment. The partition walls are moderately thick, and slightly grooved at their outer faces. The ten larger ones rise to a level with the upper end of the first ring of plates in the disk, of which they form wing-like extensions; they are sabre-shaped, and pointed at their ends. The second ring of the disk consists of four plates, which are much narrower at the top than at the bottom, and two of them are narrower than the others. The construction of the anal tube, its length, and the structure of the arms not known.

Horizon and Locality: Niagara group, St. Paul, Ind.

Type in the collection of Wachsmuth and Springer.

Remarks. The unique specimen from which the above description is made, was discovered by Mr. Charles Beachler, a very enthusiastic collector, in whose honor the species is named.

MELOCRINUS ROEMERI W. and Sp. (nov. spec.)

Syn. *Cytocrinus lævis* Roemer; 1860, Silur. Fauna West. Tenn., p. 46, Pl. 4, figs. 2 a, b, c.

Syn. *Ctenocrinus lævis* Shumard; 1866, Trans. Acad. Sci. St. Louis, p. 361.

Syn. *Melocrinus lævis* (not Goldf.) W. and Sp. (in part); 1881, Revision, Pt. II, p. 122.

Calyx moderately small, turbinate, dorsal cup about as wide as high, gradually spreading to the arm bases, which are formed into five very conspicuous lobes, giving to the calyx, as seen from above, a decidedly stellate outline. Plates without ornamentation, a little concave, except the median line of the radial plates, which is obtusely angular. The radial appendages, from which the arms are given off, composed of a single series of plates.

Basals rather large, subequal, forming a shallow cup which is slightly truncate at the lower end. Radials twice as large as the first costals, hexagonal, about as wide as high; their upper sloping faces a little larger than the corresponding lower ones. Second costals very small and curved like arm plates; their upper sloping faces unequal, that toward the outer side of the ray much longer and supporting a distichal, the inner one the first arm plate. The free rays, which consist of a single series of plates, give off the arms at intervals from alternate sides, not from opposite sides, as generally in this genus. Interbrachial spaces wide, the first plate large, succeeded by two rows of two and three plates respectively, which are followed by disk plates. The two outer plates of the upper row curve outward so as to form the sides of the lobes. At the anal side the first plate is larger, and followed by three plates in the second row, and four in the third. Ventral disk depressed, pentagonal; the ambulacral regions slightly raised above the general plane; the plates without ornamentation, almost flat, and the sutures difficult to see. The disk ambulacra are completely subtegminal; the orals apparently unrepresented, and the anus is placed at the end of a large tube which bends to the posterior side.

Horizon and Locality: Niagara group; associated with *Astraeospongia meniscus.* Decatur Co., Tenn.

Type in the collection of Wachsmuth and Springer.

Remarks. Roemer described this species as *Cytocrinus laevis*, making it the type of a new genus. He supposed it had three basals, and he did not understand the arm structure, which is evidently that of *Melocrinus.* We refer the species to the latter genus, but are compelled to change the specific name, as already Goldfuss in 1826 described a *Melocrinus laevis* from the Eifel, and replace it by *Melocrinus Roemeri.* Roemer originally included in this species two forms, the typical one from the Niagara group of Western Tennessee, and another from the same horizon of Louisville. The latter has been described by us as *Melocrinus oblongus.* The two species resemble each other in form, but *M. oblongus* is considerably larger, the calyx contains many more plates, and the tubular appendages giving off the arms are composed of two rows of brachials in place of one.

MELOCRINUS OBLONGUS W. and Sp. (nov. spec.)

A rather slender species of less than medium size. Dorsal cup obconical; the sides straight to the top of the second costals, whence the rays turn outward and form distinct lobes around the calyx, which give to the section a decidedly pentalobate outline. Plates convex, a little tumid, but without ornamentation.

Basals small, subequal, notched at the sutures, the lower face but slightly truncate and very little excavated. Radials and first costals generally longer than wide, especially the former; the second costals often as wide as long. Distichals 2x10; the two upper axillary and separated by a small interdistichal. The tubular appendages not preserved in the specimens, but, as there are two distichals to each ray, they obviously were biserial. The first interbrachial as large as the first costal, succeeded by rows of two, three, three, and three plates, which meet the interambulacrals. Anal interradius a little wider, with three plates in the second row, and four in the third. Ventral disk low, irregularly convex; the ambulacral spaces slightly elevated; the plates—orals included—almost of uniform size. Anus subcentral, at the end of a tube.

Horizon and Locality: Niagara group; near Louisville, Ky., and St. Paul, Ind.

Types in the collection of Wachsmuth and Springer.

Remarks. This form was regarded by Roemer* as specifically identical with his *Cytocrinus laevis*, which comes from the same horizon in Tennessee, and resembles it in general form; but the appendages of that species are composed of single joints, and it has a smaller number of interbrachials.

MELOCRINUS PARVUS W. and Sp. (nov. spec.)

A small and very slender species of the type of *Melocrinus Roemeri*, having, like that species, five uniserial appendages giving off the arms. Dorsal cup ob-pyramidal, the interradial spaces deeply depressed, and the cross-section at the top of the costals distinctly pentalobate. The plates a little convex, and covered with obscure ridges.

Basal cup almost cylindical, its upper end slightly wider, the lower face completely covered by the column; the plates as high as the radials, and the interbasal and basi-radial sutures distinctly grooved. Radials a little higher than wide. First costals of the same proportions as the radials. Second costals smaller, proportionally shorter, and irregularly axillary; one of their upper faces shorter and giving off an arm, the other forming the base of the free ray, which necessarily was uniserial. Interbrachials three at the regular sides, four at the anal side, the latter having three plates in the second row against two at the other sides. Ventral disk convex, the interambulacral spaces a little depressed; composed of moderately large, slightly convex plates. Anus excentric.

Horizon and Locality: Niagara group, St. Paul, Ind.

Type in the collection of Wachsmuth and Springer.

Remarks. This species differs from *M. roemeri* in the narrower and less spreading base, in the proportions of the radials and costals, and in the convexity of the plates.

NOTES ON A COLLECTION OF FOSSILS FROM THE LOWER MAGNESIAN LIMESTONE FROM NORTHEASTERN IOWA.†

By S. CALVIN, Iowa City.

Until recently we have been accustomed to regard the Lower Magnesian limestone of the Upper Mississippi valley as destitute of organic remains. Dr. White in his report on the Geology of Iowa, Vol. I, pp. 173-174, says that "the only fossils that have

*Silur. Fauna West. Tenn., 1860, p. 46.

†From the Bulletin of the Laboratories of the State University of Iowa.

been found in this formation in Iowa are, so far as known, a few traces of the stems of Crinoids found near McGregor." Whitney in Hall's Geology of Iowa, p. 337, speaking of indications of organic life in the Lower Magnesian limestone, says that "in Iowa, indeed, we have observed nothing of the kind." Owen seems to have been more fortunate than the other observers mentioned, for in his report on the Geological Survey of Wisconsin, Iowa and Minnesota, p. 60, he enumerates a few genera that are represented in this formation, but does not cite localities. The *Euomphalus* and *Ophileta* which he mentions, may be from the horizon of the Lower Magnesian limestone of Iowa; the trilobites referred to are probably from the Upper Potsdam or St. Croix group as will be noted farther on. In the Geology of Wisconsin, Vol. IV, Whitfield describes a number of species from the Lower Magnesian limestone, but it is probable that the only species referable to the horizon of the formation in Iowa is his *Euomphalus strongi* which he says occurs in cherty beds in Richland county, Wisconsin. In the Geology of Minnesota, Final Report, Vol. I, pp. 222-223, Prof. Winchell mentions the discovery of organic remains in limestone of the same age as our Lower Magnesian. The fossils occur only in cherty beds and embrace the genera *Orthoceras*, *Ophileta* and *Pleurotomaria*.

In all discussions relating to the fauna of the Lower Magnesian limestone of Wisconsin, Iowa and Minnesota, it should be borne in mind that for many years geologists have confounded the St. Lawrence limestone, a member of the Potsdam or St. Croix series, with the Lower Magnesian. In the Geology of Minnesota, Final Report, Vol. II, pp. 14 to 22, Prof. Winchell gives the results of the latest investigations on this subject and points out the true relations of the long misunderstood St. Lawrence limestone. It is possible that all the species of *Dicelocephalus*, *Conocephalites*, *Illænurus*, and other forms associated with them, which have been credited to the Lower Magnesian limestone, have come from the St. Lawrence limestone and belong to a horizon below that of the Lower Magnesian.

Within the past few years Mr. F. H. Luthe, an enthusiastic and intelligent amateur geologist, of McGregor, Iowa, has investigated the fauna of the Lower Magnesian limestone of Clayton and Allamakee counties, and has brought to light an assemblage of forms of very great interest. Mr. Luthe has kindly placed his collection in my hands for examination. All the recognizable species belong either to the Gasteropoda or Cephalopoda. Indeed all the species belong to one or the other of the above groups except some amorphous, laminated, porous structures that recall certain forms of the *Stromatoporoidea*.

The following species, all apparently confined to cherty layers of the formation, may be noted:

METOPTOMA ALTA *Whitfield*. The collection contains specimens apparently identical with the species described and figured by Mr. R. P. Whitfield under the above name in his paper on *Fossils from the Calciferous Sand-rock of Lake Champlain*, Bulletin of Am. Museum of Natural History, Vol. II, No. 2. The Iowa specimens referred to this species are larger than those from Lake Champlain. With the above occur two or three other species of *Metoptoma*.

TRIBLIDIUM, sp. There are a few forms presenting the appearance of *Capulus* or *Platyceras* that probably belong to this genus.

STRAPAROLLUS CLAYTONENSIS, n. sp. This is by far the most common species in the collection. It resembles *Euomphalus calciferus* Whitfield, Lake Champlain Fossils, p. 47, plate VIII, figs. 12 and 13. The volutions are four or more in number, circular in transverse section; umbilicus wide and deep; spire sometimes almost flat, usually slightly elevated. From *E. calciferus* W., this species will be distinguished by the fact that the volutions, in the cast, are not embracing, scarcely touching each other, and the volutions are not coiled in the same plane. The two forms are about equally robust and the whorls expand at about the same rate. *Straparollus claytonensis* differs from *Euomphalus strongi* Whitfield, in the greater number of less rapidly expanding volutions, the absence of carinæ or angles on the whorls and the pronounced difference between the umbilical and opposite sides.

STRAPAROLLUS PRISTINIFORMIS, n. sp. This is a smaller form than the preceding; volutions less robust, not embracing or slightly separated in the cast, coiled in the same plane so that the spire and umbilical sides are similar in appearance; whorls nearly circular in transverse section, upper surface of each marked by an obscure carina, with traces of another carina still more obscure half way between the middle of the whorl and the suture.

RAPHISTOMA PEPINENSE *Meek*. The collection contains many specimens of this very beautiful species. The spire is depressed and consists of about six volutions in specimens having a diameter of one inch. The periphery is sharply angulated and the umbilicus wide when compared with other species of the genus. Compare *R. trochiscum* Meek, in U. S. Exploration of the Fortieth Parallel, Vol. IV, p. 19.

RAPHISTOMA MULTIVOLVATUM, n. sp. Shell moderately large, more than an inch and a quarter in diameter; spire depressed; whorls five or more in number, increasing gradually in size, each about one and a half times as large as the preceding; each whorl bears an obtuse angular carina near the suture; suture somewhat deeply impressed; upper surface of each whorl concave; outer margin marked by a sharp angle from which the convex lower surface of the last whorl slopes downward and inward to the angle that bounds the umbilicus.

RAPHISTOMA PAUCIVOLVATUM, n. sp. This is a small lenticular species having from two to two and a half very rapidly expanding whorls.

HOLOPEA TURGIDA *Hall*. There are a number of specimens indistinguishable from this species as it is described and figured by Hall, Billings and Whitfield. See Paleontology of N. Y., Vol. I, p. 12, plate III, figs. 9 and 10; and Lake Champlain Fossils, by Whitfield, p. 50, plate IX, figs. 3-7.

MURCHISONIA, sp. There are a few specimens referable to this genus. They are characterized by an elongate spire with many sharply angular volutions.

ORTHOCERAS PRIMIGENIUM *Vanuxem*. This species is well represented by two or three specimens, all showing the characteristics by which it may be readily distinguished. See works of Hall and Whitfield already cited.

CYRTOCERAS LUTHEI, n. sp. Shell rather small, elliptical in transverse section, only moderately curved; length of an average specimen from two and a half to three inches, greatest diameter of body chamber three-fourths of an inch; septa very numerous, ten chambers occupying the space of half an inch; septa oblique to the axis, rising highest on the convex side, the obliquity increasing as the septa approach the chamber of habitation; siphuncle large for the genus, situated close to the inner or concave margin, tapering more rapidly in proportion to size than the shell, and expanding to a trifling extent between the septa. Outer chamber long; margin of aperture and surface markings unknown. This species will be readily recognized by its elliptical section, its oblique, closely crowded septa, and its large, internal, rapidly tapering siphuncle.

The specific name is given in honor of Mr. F. H. Luthe, of McGregor, Iowa, to whose skill and enthusiasm science is indebted for valuable additions to our knowledge of the fauna of the Lower Magnesian limestone in the valley of the Upper Mississippi.

The collection contains fragments of other species that will sometime, we hope, be represented by identifiable specimens.

In general aspect this fauna resembles that of the Calciferous sand-rock about lake Champlain. The identity of the species in some cases and the close resemblance in others, leaves little doubt as to the exact equivalency of the Lower Magnesian limestone of Iowa with the Calciferous series of northeastern New York.

Geological Laboratory, University of Iowa, May 25, 1892.

THE SCOPE OF PALEONTOLOGY AND ITS VALUE TO GEOLOGISTS.

Address before Section E., A. A. A. S., Aug. 17, 1892, by H. S. WILLIAMS, New Haven, Conn.

The scientific study of fossils is scarcely a century old. It was in 1796 that Cuvier for the first time ventured to say that certain fossil bones found in the Paris basin represented an *extinct* species of elephant.

About the year 1819, William Smith became famous by proving that rock strata could be traced across the country by their fossils, that at each outcrop across miles of interval a stratum could be recognized by the identity of the fossil shells it contained.

Previous to this, fossils had been regarded as curiosities. Cuvier and Smith made it clear that fossils tell us of organisms of whose existence or nature we should otherwise be ignorant, and that the kinds of organism are, somehow, related to the different strata of rocks.

Deshayes who was a friend of Lamarck, and Lyell, and a little later, William Lonsdale were among the first to demonstrate the wide scope of paleontology and its inestimable importance in the interpretation of the problems of geology.

Lyell tells us in his "Antiquity of Man," (p. 3), of the method he employed in determining the subdivisions of the Tertiary: "When engaged in 1828" (he writes) "in preparing for the press the treatise on geology, above alluded to [the third volume of

'Principles of Geology'], I conceived the idea of classing the whole of this series of strata according to the different degrees of affinity which their fossil Testacea bore to the living forms. Having obtained information on this subject during my travels on the continent, I learned that M. Deshayes of Paris, already celebrated as a Conchologist, had been led independently, by the study of a large collection of recent and fossil shells, to very similar views respecting the possibility of arranging the tertiary formations in chronological order, according to the proportional number of species of shells identical with living ones, which characterized each of the successive groups above mentioned."

The view of M. Deshayes may be given in the words of Robert Bakewell, as found in the 5th edition of his geology (p. 399, 1838). He writes:

"M. Deshayes considers that the relative ages of different groups of strata or formations may be determined by their zoological characters alone; that is, by the species of shells they contain. He forms two grand divisions of stratified formations: 1. Those which contain no species of shells analogous to existing species [meaning *identical* species]. This division is stated to comprise all the secondary strata. 2. Strata which contain a greater or lesser number of species analogous to existing species. The last division comprises all the tertiary formations. Again he subdivided this division into three groups, according to the greater or lesser proportion of species of shells that they each contain analogous to living species." (Bakewell's Introduction to Geology, p. 399).

The law here propounded is quite different from that announced by William Smith. "That each stratum contained organized fossils peculiar to itself, and might, in cases otherwise doubtful, be recognized and discriminated from others like it, but in a different part of the series, by examination of them." (Phillips' Memoirs of William Smith, p. 15.)

Smith's law considers only the significance of fossils as marks indicating the stratum to which they belong. Fossils studied and described on this basis, are at best but "Medals of Creation," *i. e.*, the classified signs by which geological formations may be recognized. This is the scope of the older paleontology. The higher or comparative paleontology as set forth by Deshayes, Lyell and Lonsdale considers the relationship which fossils bear to each other, to those which preceded them and to their successors. It deals with the history of organisms, and therefore is able to find in fossils themselves the evidence of the order of sequence of the rocks containing them.

I quoted from Bakewell, because he considered Deshayes' and Lyell's methods as innovations. When, in 1833, he wrote the preface to the fourth edition of his geology, he expressed his contempt thus:

"Great importance," he says, "is attached to the study of fossil shells; but the character of the animals that inhabited them, of the power they might possess of modifying the form of the shell under various circumstances, has scarcely been thought of. Some French conchologists are endeavoring to establish the doctrine that fossil conchology, independent of the succession and stratification of rocks, is the only true basis of geology; and a trifling difference in the form of a shell, is deemed sufficient to constitute a new species, and to warrant the most important conclusions respecting the age of the rock formations."

This was sixty years ago, when the general belief was that species are immutable, and therefore that new creation was necessary to account for distinct species. The geologists recognized the importance of species as indication of the age to which the containing rock belonged, and fossils were regarded as particularly valuable in classifying and identifying the stratified rocks, but the question was raised by Deshayes and Lyell—"Is there not a natural sequence in the order of the successive species?" Lyell evidently did not for several years realize the full import of the question he propounded when he spoke of the relative affinity of the species.

William Lonsdale, in 1839, made a still higher application of paleontology, in his determination of the fossils of South Devonshire to be of intermediate age between the Carboniferous and Silurian systems, which led Sedgwick and Murchison in the same year to propose a Devonian system as of the same age as the Old Red system, though containing no fossils of the same species.

The conditions were these: Murchison had recognized the "Carboniferous limestones" and the following "Coal Measures" in northern England containing their characteristic fossils. In the Cheviot hills the "Old Red sandstones" were found below them, with their fish remains.

In western England the "Silurian system" with its marine fossils was known to run upward into rocks with similar remains, considered to be the lower Old Red sandstone.

And the order, (1) Silurian system, (2) Old Red system, (3) Carboniferous system, it was believed, expressed a continuous stratigraphical series. When certain fossils from the limestones of Newton, Bushel, and other localities in South Devonshire were given Lonsdale to describe, he determined them to be of the age of the Old Red sandstone, in the following way, (to use his own language): "It was therefore by combining together this evidence, the presence, in the same series of beds, of shells resembling or identical with Mountain limestone species, of Silurian corals, the *Calceola Sandalina*, and various distinct Testacea, that I was induced to suggest that the South Devon limestones are of an intermediate age between the Carboniferous and Silurian systems, and consequently of the age of the Old Red sandstone:" (Notes on the age of the Limestones of South Devonshire by William Lonsdale, F. G. S. [read March 25, 1840] Trans. Geol. Soc. 2d Sec., Vol. v., p. 721.)

Sedgwick and Murchison adopted Lonsdale's conclusions without reserve, although they produced radical change in the classification they had already published, and on the strength of them they founded the Devonian System, and said: "This is undoubtedly the greatest change which has ever been attempted at one time in the classification of British rocks," and further, "So far from thinking ourselves rash and hasty in drawing the preceding conclusions, we think we may rather be accused of being over-cautious and tardy in accepting evidence, however opposed to commonly received opinions."

(Sedgwick and Murchison, "On the Physical Structure of Devonshire, etc., Pt. II, on the Classification of the Older Stratified Rocks of Devonshire and Cornwall," Trans. Geol. Soc., 2d Sec., Vol. v, p. 688.)

This interpretation was not stratigraphical, nor was it a case of correlation by means of a common species of fossils, after the William Smith method of paleontology, but it was a case of determining the stratigraphical position of the Devonian fauna by a comparison of its species with those of other faunas from which it differed. It is a typical case of what I would call Comparative Paleontology.

In both of the cases cited it will be noted that the fundamental fact underlying the determinations made, consists in the recognized natural order of sequence of species corresponding to the stratigraphic order of the rocks containing them.

It is not probable that any of these early paleontologists understood the full meaning of this sequence, and we are hardly yet able to see how much the studies of the paleontologist have done to establish the derivative theory of evolution. But it is becoming every day more and more apparent that the reason for its great value to geology and for the grandness of the scope of paleontology is the fact that its subject matter is the records of the history of organisms.

To the comparative paleontologist, fossils are hieroglyphics, which tell more fully than those of Egypt and Persia of the habits, customs, migrations and environments of the successive races from the beginning of the world. Although the stratigraphic order is all important in reading them, when the clue to the story is found, the fossils are as much more important than the stratigraphy (to the correct interpretation of geology) as the meaning of a sentence is more important than the succession of the words on the page.

But I speak here of the scope of the pure science. Before this audience I would call particular attention to the value of comparative paleontology to the geologist, as a means of determining the structure and development of the earth.

Lyell was the first to use paleontology as a means of classifying geological formations. In establishing the divisions of the Tertiary, *i. e.*, Eocene, Miocene and Pliocene, he made a numerical comparison of the faunas themselves. This method has its imperfections, but the fundamental truth underlying its application is that there is a natural order of succession in the history of organisms whose remains are preserved in the strata. This order of succession is observable in respect of three different sets of characters:

(1.) The parts or *organs* of which each individual organism is composed.

(2.) The separate *species* existing at any particular time.

(3.) The combination of species into *faunas* or *floras* which are associated with certain conditions of environment.

In the first case we know how the organs arise, not ready made, but in each individual by gradual modification of the organless germ one after another the various parts and organs of the adult are perfected. The paleontologist has learned that in some general way, at least, the natural sequence of form of organs has followed the same law. As among vertebrates, the multirayed fin of the fish, the webbed paddle of the enaliosaur, the paw of the crawling reptile, the hand of man form a natural sequence of development, the later in each case presupposing the preceding stage.

In the second case it is well known that there is a natural succession of species. This succession points to genetic relationship between successive species, and it is an established law of this succession that species most like each other occur near together in the chronologic order, and species of the same genus, presenting the greatest divergence from each other, are also the more widely separated in time.

In the third case it is known regarding living organisms that they present natural association with each other and in adaptation to the various conditions of environment. The law of this association is expressed by the terms fauna and flora. Paleontology teaches that the faunas and floras change, and, as the law of Lyell illustrates, that this change is gradual and in a definite order. The individuality of a fauna can be recognized and can be followed out in its successive changes, and these changes are best explained by the law of adjustment to environment.

In the series of modified organs we see the law of *organic development*, in the series of successive species of a race, the law of *hereditary evolution*, and in the composition and changes of successive faunas the law of adjustive *adaptation to environment.*

It is an expression of these laws that the fossils become such delicate tests of the chronological order and the geological conditions of the past.

In the interpretation of the divisions of the Tertiary, Lyell observed the law of succession of a single fauna, and, for a single continuous fauna, the gradual accession of new species and extinction of old would express a normal law of succession. If, however, two faunas are compared, the number of common species would depend upon the likeness or difference of the environing conditions.

To apply the Lyellian principle correctly, it is necessary to compare the successive faunas of the same province, and for the recognition of the province too, it is necessary to consider the possible change of climate, or the effect of the shifting of conditions by elevation or depression of the bottom, or change of relation of surface of sea to surface of the land.

This principle involves the fact that each species has a limited life period, but it does not involve, in Lyell's first usage of it, the fact that one species is necessarily descended from another.

Before this latter law was accepted as a fact, the natural sequence of species, and of genera and orders was known. Lamarck had advanced the idea of the spontaneous origin and progressive development of the organisms of the earth, but it is interesting to note the fact that the natural sequence of different orders of beings was generally accepted before it was granted that natural descent was the explanation of the sequence. Deshayes maintained that the species of the Cretaceous were all extinct, and in this fact was found the ground for separating the Tertiary order of rocks from the Secondary, the former alone containing shells identical with those now living.

The laws of geographical distribution, with resultant modifications of those combinations of species called fauna and flora, and the modification of the species themselves in their adjustments to changed environment, are sufficient to explain the imperfections of the Lyellian principle of determining relative antiquity of formations by the mere numerical proportion of recent species they contain, but as a general principle it is satisfactory. The same principle of numerical comparison when applied to genera, families and orders furnished the basis for the classification of the geological series into Cenozoic, Mesozoic and Paleozoic.

The mere numerical comparison of faunas is incapable of very minute application in marking the chronological scale, for the reason that the life period or range of species is often equal to that of a geological period, and the life period of a genus may span two or three systems. In these particulars I refer specially to invertebrates. Land vertebrates express a much greater sensitiveness to changes of environment, but as a means of determining the geological age of strata, they are of such rare occurrence as to be practically useless for the general geologist. Vertebrates when they are present, as well as plants, are of extreme value as time indicators. Thus it is evident that we owe to comparative paleontology, and not to stratigraphy or lithology, the primary classification of the geological scale, and the means of distinguishing the chronological position of each formation.

A second invaluable service of paleontology to geology is found in the application of the law of succession of the great groups of organisms. In the history of vertebrates we are all familiar with the law of succession: (1) Fish, (2) Amphibians, (3) Reptiles, (4) Mammals, and in another line, (3) Reptiles, (4) Reptilian Birds, (5) Birds.

The finding of remains of any one of these groups of animals is sufficient evidence that representatives of the lower type had previously existed. The abundance of reptilian remains is certain indication of later age than the Paleozoic; the abundance of mammals, of age later than Mesozoic. In the same way the trilobites are known to be an ancient type, and the decapods a more modern type of Crustacea. The Tetracoralla are older than the Hexacoralla. And a great number of similar instances can be named, where, in a particular class or order of organisms, there is a definite succession in the order of their dominance and theoretically it is believed also, in their initiation. A third application of paleontology is made by the comparative study of species of a particular genus, or the genera of an order. In each genus there is observed to be a period of particular abundance before or after which there is more or less rapid diminution in the number of species found. Thus the brachiopods, so abundant all through the Paleozoic rocks, present a definite order of sequence in the genera and families, relative abundance of species of which, irrespective of specific names, is a reliable indication of geological age. The Cambrian is indicated by the abundance of its Obolidæ and other inarticulate genera, the lower Silurian by abundance of Orthidæ and Strophomenidæ, the upper Silurian by numerous genera of Strophomenidæ, Pentameridæ and Rhynchonellidæ, the Carboniferous by dominance of the Productidæ, the Mesozoic by dominance of Terebratulidæ and absence of the Paleozoic types. So, too, the Cephalopods furnish a scale of families which present a natural sequence, the Orthoceratidæ, the Goniatitidæ, the Ceratitidæ, the Ammonitidæ, and the dominance numerically of these several divisions at once testifies to the 1st half of Paleozoic, the 2d half, the 1st half of Mesozoic, the second half of Mesozoic, and absence, or almost total absence of each, to the Tertiary and Recent.

Less is known of the succession of species in continuous series as indicative of order of time. The famous case of the classification of the beds of the Lias by its Ammonites is a characteristic example. Oppel, Wright, Buchman and others have studied the

Ammonites peculiar to each stratum and classified and defined successive zones thereby.

The name applied to each zone is the specific name of the Ammonite peculiar to the bed, as

Zone of *Ammonites* (*Aegoceras*) *planorbis*, the planorbis bed.
" " " " *angulatus*, angulatus bed.

And so on, *bucklandi*, *tuberculatus*, *obtusus*, etc., beds.

Although this is not the purely comparative method, but is rather an extension of William Smith's principle of recognition of the beds by their fossils, the comparative element is seen in the succession of distinct species in succeeding comparatively thin beds. The studies of Branco and Hyatt expanded the investigation to a comparative study of the series of Ammonites of a single genus, and brought out thereby the exact laws of succession of the several known representatives of the family and their relation to each other, showing unmistakable succession in series of forms, whose order can be accounted for only as genetic.

Hilgendorf, in his famous study of the *Planorbis* of Steinheim and Waagen with the *Ammonites*, Neumayr with the *Paludinas*, Hörnes in the case of the *Cancellaria*, have traced elaborately the paleontological series of forms of a single genus, illustrating this important principle.

In the case of the Pliocene *Paludinas* examined by Neumayr, a series from below upward was traced, which at the base exhibited a normal *Paludina* (*P. neumayri*) and the latest of the series, (*P. hoernesi*) was not only regarded as specifically distinct, but as the type of a distinct genus, *Tulotoma*. (See Neumayr, p. 57.)

Prof. Hyatt has elaborately traced out all the known species of the *Arietidæ* in the same way, and arranged the different forms in series exhibiting their chronological mutations. Waagen applied this term "*Mutation*" to the modification of form observed on comparing the successive representatives of such series, to distinguish it from the modifications which are exhibited contemporaneously, and are defined under the terms "variation" and "variety." The series of fossil horses described by Marsh and Huxley is another case in which the "mutations" reached a generic value.

All through the field of paleontology may be found similar series of genera in which the succession is of such a nature as to suggest genetic relationship and to lead to the theoretical construction of phylogenetic lines of descent.

Although it may be rightly objected that evidence is in most cases extremely imperfect, and in attempts to fill out paleontological series imagination has been freely used in filling the gaps, there can be no question as to the immense value to geology of the knowledge already acquired in this highly theoretical part of paleontology.

It is the *differences* observed on comparing fossils coming from different horizons and different regions that are of value in these determinations, and not the *numerical proportion* of identical forms, as in the William Smith method of identifying strata.

It is the direct interpretation of observed variation and mutation of organic forms into terms of the amount of geological time and the extent of change in environment.

This comparative paleontology, to be accurately used, must deal with the finer details of form and structure, because the evidence of genetic affinity must be perfectly clear before the series can be depended upon as expressive of the true order of evolution.

A remark should be made here upon the limitations to the use of fossils as indicative of geological age.

Granting the general proposition that the differences exhibited by different species of the same genus are variations and mutations in the descendants of a common stock, still it is not possible to decide *a priori* what the rate of the modification may have been. Certain modifications are undergone in a season during the ontogenetic development of the individual from the germ cell to the adult. In the same way examination of a large number of cases in different groups of the Animal Kingdom, shows that in many cases there is in the early stage of the life history of a new genus, rapid expansion in specific modification, and later on each specific line appears to express only very gradual "mutation" in respect of certain characters in which at its early stage it was definitely variable. In other words, upon studying the life histories of species there appears good evidence of an *initial stage* in which the species present characters in a plastic state; later these characters became fixed in each genetic line, and the species appear, on this account, to be more distinct in their characters. Hence the amount of difference exhibited between two species will not arbitrarily indicate their distance apart in the genetic series.

Also different genera exhibit different rates of mutation. It results therefore that the law of mutation must be studied separately for each genus, and even then the accelerative effect of changed environment is not known, although it is within the reach of investigation.

Another difficulty in the way of close application of these laws in determination of age is that *a priori* it is impossible to tell whether the differences exhibited by two closely allied forms are *varietal* and associated with changed environment, or *mutational* and associated with the paleontological evolution of the race.

The study of these problems must therefore be intimately associated with minute regard to stratigraphic sequence, just as in deciphering a manuscript, the succession of the words is essential to a correct interpretation of the writing.

The way in which the paleontologic record supplements the stratigraphic evidence is seen in the fact that the paleontology is capable of showing gaps or omissions, the length and nature of which cannot be calculated from the strata themselves.

Another mode of investigation has been employed in which the modifications of a particular part of an organism are made the subject of inquiry.

The case of the toes of the ancestors of the horse, from the five-toed Eohippus to the one-toed modern horse, the camels, from the Poëbrotherium of the Miocene to the Pliocene and recent Auchenia, as shown in the bones and in the teeth, are examples.

A typical illustration is the development of the sutures of the tetrabranchiate cephalopods.

It will be remembered that the distinguishing feature of the cephalopod shell is its chambers, thus separating it from the shell of the gasetropod. The edges of the partitions forming the chambers where they meet the external walls of the shell, are technically called sutures. In the Nautilian shell, whether exhibiting a simple elongated cone as in Orthoceras, or a curved horn as in Gyroceras or Cyrtoceras, or a close coiled shell as in Nautilus, the sutures are simple. In other groups of chambered shells the suture line is wavy, forming lobes and saddles or variously crimped, as in Goniatites or Ceratites.

These suture lines form a regular series which both in time of initiation and in the period of dominance express a simple law of evolution.

Every geologist is familiar with the more apparent features of the series as seen in the genera *Nautilus*, *Goniatites*, *Ceratites* and *Ammonites*.

The various degrees and forms of lobes and saddles are the basis of elaborate classifications and systems of names proposed by Beyrich, the Sandbergers and others, but up to the present time I think we have not a published classification which recognizes the fundamental law of evolution expressed in the series.

In analyzing the forms of suture, for my class in the History of Organisms, I found the following simple law to exist.

The various suture lines of the chambered cephalopod shells can be distinguished by the differences in degree of complexity of the crimping of the edge of the septum.

Viz: (a) In the *Orthoceran* and *Nautilian* type, the edge of the septum is straight, or the curving is not enough to produce more than a single oscillation of the suture line during its complete circumference.

(b) The *Goniatite* septum presents a lobed suture, but the edges of all the lobes and saddles are simple.

(c) In the third type the lobes and saddles are variously crenulated. In the *Ceratite* the crenulation affects the base of the lobes, in *Helictites* the top of the saddles is crenulated, and in *Mendlicottia* the lobes, the saddles and the connecting parts of the suture are crenulated.

(d) In the typical *Ammonite*, there is a tertiary crimping of the suture line, *i. e.*, each of the archings of the line corresponding to the crenulations of Mendlicottia is again crenulated, forming a complexly foliate suture.

(e) In the adult forms of *Pinacoceras* there is a still further elaboration of the crimping, the tertiary archings of the Ammonite are again crenulated, forming a quaternary stage of corrugation.

The series presents a gradual elaboration of the crimping of the edge of the septum, forming a suture line, 1st, *simple*, 2d, *primarily lobed*, 3d, secondarily corrugated or the *crenulated type*, 4th, tertiarily corrugated or the *foliate type*, and 5th, the *quaternary corrugations* of Pinacoceras.

In their historical bearings it may be said of this series that,

1st. It is the order in which the various types make their first appearance in the geological series.

2d. It is the order in which the several types become dominant.

3d. It is the order of elaboration in the ontogenetic growth of the individual.

4th. It is the normal order of physical relation borne by the several types to each other; each type is a physical elaboration of the next preceding type.

The convolutions of the suture are crimpings of the edge of a more or less flat disc—the septum—and these convolutions are the simplest mode of adjustment of the edge of such a disc, whose circumference increases more rapidly than its radius.

Assuming this sutural feature to be the only difference involved in the comparison of the several types, it would be correct to state that it would be physically impossible for the Ammonites, septum and suture to be formed without passing through the stages represented by the Nautilus, Goniatites and Ceratites. In other words the exhaustive analysis of this one element of structure of cephalopod shells shows us that the actual history of the organisms has been exactly that which a serial classification on the basis of differences of this part would suggest, but that no other classification or order of succession could take place by natural descent. It is unneccessary to speak of the value of such series for purely stratigraphical purposes.

It is but one of a great many such mutations to be discovered in the study of comparative paleontology. The general law involved is this: in a series of genetically related forms in which the ,later representatives present a character which is but the physical elaboration of that found at a much earlier stage, there is implied the presence in the intermediate formations of species in which the character is in an intermediate stage of development, and of a continuous series connecting the extreme forms.

I have thus far spoken of the general scope and application of comparative paleontology. I might cite many cases in which particular problems have been settled by the use of these methods, and refer to the works of Neumayr, Waagen, Kayser, Barrois, Gosselet, Frech, Tscherneyschew, and others in Europe, to the investigations of Hall, Whitfield, Whiteaves, White, Marsh, Cope, Walcott, Herrick, Hill, Prosser, Keyes, Clarke, and of Meek, who was one of the keenest of our earlier paleontologists. And there are many extremely valuable special investigations like those of Agassiz on the echinoids, Hyatt on the cephalopods and those of their followers, Jackson, Beecher and others. But at the present time it will be impossible to speak of them, even were I able to do them justice. I will, however, beg your attention to a series of paleontological investigations, with the details of which I am more familiar, and the steps of which are more or less related to each other, and have, collectively, resulted in throwing considerable light upon the geology and geography of the Devonian system. As I have already said, the Devonian system was originally founded upon purely paleontological evidence. The question as to the lower limit of the Devonian in this country has been a purely paleontological problem, and the reason for including the Oriskany in the Devonian is because the fauna is more closely allied to that of the Looe and Cornwall slates, the Gedinnien and the Coblentzien formations of Europe, than to the Silurian faunas, and presents a larger proportion of species which connect it with the Corniferous faunas above than with the Helderberg below. (See Hall's list of species in 42d Annual Report of New York State Museum.)

The correction of the "Chemung" of Iowa and Missouri and the adoption of de Verneuil's earlier interpretations of the Carboniferous age of the fauna as perpetuated in the Kinderhook group, was settled by the evidence of fossils.

The Hercynian question of Europe was debated on paleontological, not stratigraphical grounds.

In 1881 the minute study of *Spirifera lævis* leading to the prediction that the character by which Davidson distinguished the lower Devonián *Spirifera curvata* from the Carboniferous *Spirifera glabra* would be found upon the higher form as well, which afterwards Davidson confirmed, was the first step toward distinguishing the fauna of the upper Devonian of eastern America from the middle Devonian fauna as to its origin.

The suggestive fact in this case was that this rare American upper Devonian spirifer was more closely allied morphologically to a common lower and middle European species than to any preceding American form. This thought led to a thorough dissection of the Devonian faunas of New York and neighboring states.

The series of successive faunas along a common meridian were tabulated and compared. The sections were made parallel to each other and near enough together to make it possible to compare corresponding zones of the several series. By this method the law was established that the composition of a fossil fauna changes on passing geographically from one place to another. Upon tracing single species across these sections it was learned that the mutation of the species, not only may be recognized on passing vertically upward through a continuous section, but that the more direct line of succession was often deflected laterally so that the immediate successor of a particular fauna of one section was found not directly above it in the same section, but at a higher horizon in a section ten or twenty miles distant. This *shifting of faunas* was taken as actual evidence of migration and was interpreted as the result of oscillations of level.

The examination of the remarkable fauna of High Point, at the southern end of Canandaigua lake (the locality of which was first shown me by Mr. J. M. Clarke), furnished me with still further clue to the solution of the origin of the faunas. I recognized, at once, upon seeing it, that it was related to the Iowa Devonian, and differed widely from the typical upper Devonian of New York, in the midst of which it lay.

Further analysis of the fauna led to the discovery that the species peculiar to it apparently had their ancestors in the middle Devonian of Europe rather than in any middle Devonian of America. With this stage of progress I examined the fauna peculiar to the Tully limestone. Much confusion had been thrown about it by the publication of a large number of species as "known" Tully fossils. Special search was made in original localities with the result of eliminating a large number of reported species which were found immediately below the true Tully limestone in the calcareous termination of the Hamilton, where the typical Hamilton fauna is very abundant, and the true fauna which I described as the *Cuboides fauna*, was carefully compared with that of every locality in the world of which I could find report of its presence. The result showed that in eastern America where the Tully appears, the fauna of the Cuboides zone begins abruptly, and from it upward, all through the upper Devonian, is a fauna closely related in its species with the upper Devonian of Europe, Russia, Siberia, China and British America, and down as far as Iowa in the interior, the Nevada Devonian also showing close affinities with this type or fauna.

But in Europe, where the statistics are abundant and clear, and so far as evidence bore upon the fact, also in Russia, Asia, and British America, the Cuboides fauna is the natural successor of the middle and lower Devonian of those regions.

Mr. Whiteaves, in his recent studies of the British American Devonian along the McKenzie River valley, adds many points of confirmation of this view, as in some species like *Stringocephalus Burtini*, which had not heretofore been known in America, but were characteristic of certain middle Devonian of Europe.

These purely paleontological investigations had proved, with a high degree of certainty, that, relatively speaking, the Tully limestone marks a chronological point in the strata which within relatively small limits may be said to be chronologically and not merely taxonomically the same as the Cuboides zone of Europe and Asia, and, second, that the upper Devonian faunas of these several regions are more closely allied than the typical upper Devonian fauna of New York is to its typical middle Devonian fauna of the same area.

This is a very important conclusion, and the principle involved is of vast importance in further studies of comparative nature. It makes necessary the tracing of the geographical distribution of species in order to get accurate data for the interpretation of their geological succession.

As confirmation, however, of the above conclusion, there has recently appeared a paper by Steinman and Ulrich on the "Devonian fossils of Bolivia," in which we are shown the origin of the middle and lower fauna of New York and eastern America.

By the comparison of the Devonian faunas of Bolivia, the Andes, Brazil, Falkland islands and South Africa, Ulrich reaches the conclusions as to their natural affinities with each other, and with the lower and middle Devonian faunas of eastern North America, and as remarkably distinct from the corresponding faunas of Europe and northern Asia.

Not only does the presence of peculiar species link together these several regions and separate them from the northern set of regions, but some of the more characteristic species of the southern hemisphere type, as *Vitulina* and *Leptocœlia*, are abundant and common to many localities and of higher range in the southern hemisphere and are rare or confined to lower horizon in the Appalachian Devonian of North America, thus indicating their extra-limital range in the latter region.

In the determination of the genetic affinities of the faunas of the southern hemisphere with those of the lower and middle Devonian in North America, just as in the tracing of the affinities of the Tully limestone fauna and upper Devonian, it is not the identity of species or the majority of species in contrasted regions that plays the greatest part, but it is the testimony of the somewhat isolated forms, whose local distribution is traceable, and also by the breaks in successive lines of species which are associated together as races, though the species at each stage or in different regions may be described under different names.

In the study of the Cuboides zone, it was such species as *Orthis tulliensis*, *Strophodonta mucronata var. tulliensis*, *Rhynchonella venustula*, which told the tale, each differing specifically from any European species, but belonging to races, which in Europe had representative species extending from the Silurian through the Devonian into the Carboniferous system, but in the Appalachian region lacked representatives in the middle Devonian, though well represented in the upper Devonian of New York, and were represented also throughout the Devonian deposits in the Nevada and Iowa areas. The continuance of the European type above this zone in the Appalachian region was also testified to by such species as *Spirifera lævis* and *Spirifera disjuncta*, *Productus dissimilis* of Hall (*hallianus* of Walcott), *Orthis impressa*, *Rhynchonella pugnus* and others, which are well represented in the fauna above the Cuboides zone, but have no forerunners in the Appalachian higher than the lower Helderberg (in rare cases seen in the Corniferous), while in the European faunas there are connecting species all through the middle Devonian, thus pointing to a change of fauna, not by *extinction* of the species, but by *migration* from one region to another. Just as the presence of the bones of *Mylodon*, *Megalonyx*, and the tapir in the United States, now extinct in North America, indicates a former extension of the South American living fauna of mammals into this continent.

It was by a similar method that Dr. Ulrich traced the historical relations of the Hamilton fauna of the Appalachian province in eastern North America to the southern hemisphere. In his description of the Bolivian fossils collected by professor Steinman, he made comparison not only with the species, but with the faunas of Brazil collected by Hartt, Derby and Rathbone, and of South African and Falkland islands' faunas described by Salter and Sharpe. The most striking evidence of the affinity of these several faunas was derived from the study of three rather abundant genera of brachiopods; *Leptocœlia*, *Vitulina* and *Tropidoleptus*, genera which I would describe as old type genera for this Devonian period, *i. e.*, preserving the form and general characteristics of the lower Silurian Orthidae and Strophomenidae but assuming the later character of calcified brachial supports of the *Terebratulas* and *Spiriferidæ*. This is the case for at least the first two genera, and *Tropidoleptus* possesses the punctate structure characteristic of the Terebratulas.

Dr. Ulrich observes that *Leptocœlia* is found in North America, particularly in the eastern part, in Bolivia, on the Falkland islands and in South Africa, but not a single trace of it has been reported from the Devonian deposits of the other regions, Europe, Asia and Australia, and that the South African and South American species reach larger dimensions than those of North America (pp. 62, 63).

A point bearing upon the general discussion, which Ulrich did not observe, is the fact that this Leptocœlia fauna extended northeastward as far as Quebec, Maine and Acadia, and in this region is the terminal marine fauna of the Devonian. There was evidently a barrier already separating the European sea from that of the Appalachian region, and the connection with the South American faunas was by the southwest. This in some measure may account for the conspicuous absence of characteristic European types in the Appalachian Hamilton faunas.

In regard to the *genus Vitulina*, Dr. Ulrich remarks that it appears in America, but is there a rare species in the later Hamilton, "While" he says, "it is in South America apparently present in each of the hitherto discovered Devonian regions," viz., the province of Para in Brazil, as reported by Rathbone in Coati Island, Titicaca lake, according to Agassiz and Garman, the province of Sao Paulo, reported by Derby, Central Brazil by Smith, and in Bolivia, in several localities, by Steinman, South Africa, Schenk, (pp. 73, 74.) But it is entirely wanting in Europe, Asia and Australia. These facts show the type to be peculiarly a southern one, but it may still further be remarked that the *Vitulina* is in America isolated and above the horizon of *Leptocœlia*, whereas in the Bolivian region it is not only associated with *Leptocœlia*, but is common and appears also in other apparently higher zones in association with *Tropidoleptus*, which later in South America is not found associated with *Leptocœlia* indicating that the North American appearance of the type is extra-limital and later than its greatest dominance in South America.

Tropidoleptus shows a different history. It is seen in Europe as well as North and South America and Africa, but in North America it is associated with a southern origin, for while it is particularly a Hamilton species and of the Appalachian province chiefly, it runs up into the upper Devonian of eastern New York, and is seen above the Cuboides zone. But it is wanting in the Mackenzie river basin fauna (Whiteaves, "The Fossils of the Dev. Rocks, etc., 1891), which is the Devonian of European-Asia. In the European fauna it seems to be confined to a lower horizon, the Coblenzien of Europe or the Looe slates, while in America it is more characteristic of the higher part of the Hamilton, and in Central New York is even a Chemung species. It is reported from Illinois and Iowa, but is evidently a rare form in those faunas, and in Nevada, where it is in the lower Devonian as it is in the European faunas. Thus its range in the Devonian deposits of the Appalachian region points to its association with the southern faunas and migration with them after their general separation from the European faunas, whose connection with North American areas was by way of Asia and across the Pacific basin after the close of the Silurian, rather than by any connection across the Atlantic basin.

The other species cited in Ulrich's paper on "Fossils of Bolivia" support the same conclusion that there was a close relationship existing between the Devonian faunas of South America and south Africa and the fauna in the Appalachian trough, reaching as high as the Hamilton formation, and that this general fauna was distinct from the European-Asiatic faunas of the same period. This differentiation of the lower from the upper Devonian faunas occurring in the Appalachian region, and tracing them to centres of geographical distribution in opposite hemispheres of the globe, throws light upon certain other important geological problems concerning the Devonian deposits of North America.

As we follow the elaborate series of Devonian formations of

New York southwestward across Pennsylvania, Ohio and Kentucky, we gradually lose the separate members, and black shales become conspicuous in their places, and in Tennessee there is but a thin black shale to represent this whole interval, and in northern Alabama scarcely anything separates the Silurian (in some cases lower Silurian), from the Carboniferous resting unconformably or even conformably upon it. Similar conditions are seen in northern Arkansas, where, about the Ozark uplift, the erosion of the Silurian terrane is such that at the corner of Illinois, Helderberg, Oriskany and even traces of Hamilton are left in place, while further west, the latest is Helderberg, or Niagara, or Trenton, and at extreme points magnesian limestone was the surface rock when the black shale was deposited, to be immediately followed by typical Carboniferous fossils.

In Texas we find a similar cutting out of the Devonian, and more or less of the upper Silurian and the Carboniferous following the interval.

These facts point to an elevation sufficient to occasion extensive erosion toward the southwest, followed by depression, which gave occasion for the deposit of the black shale over extensive areas. If we are correct in tracing with Ulrich his Bolivian Devonian fauna to South Africa and recognizing it in the lower and middle Devonian faunas of the Appalachian area of North America, and in inferring, as I have suggested, that the change in fauna at the close of the Hamilton in New York was associated with the arrival of the Cuboides fauna into the Appalachian region, and thus that the upper Devonian is distinctly a European-Asiatic fauna and connected with it across the Pacific down the Mackenzie region, it is evident that the time of the change of these faunas corresponds with the time of the geologic events in the southern central part of the United States, above referred to. The elevation which occasioned the erosion did not take place till the Hamilton period, and the depression and deposit of Black shales followed the incursion of the new fauna, or was, in part, contemporaneous with it.

The erosion ceased and the deposition began in the south later than in the north, as is indicated by the fuller representations of the separate deposits at the north than at the south, also by the smaller amount of the deposits, as indicated by the gradually thinning black shale on passing from Ohio across Kentucky to

Tennessee and Alabama. It was as early as the age of the Oriskany that the separation of the typical southern from the typical northern faunas took place, and in the extreme northeastern extension of the Appalachian region, the Acadian province of Maine and New Brunswick, we observe that this is the highest marine fauna reached in the Devonian.

Elevation evidently shut out access to the sea for this region. It is from that time on that the faunas of the Appalachian region present their essential relation to the southern hemisphere faunas, and show the absence of the typical European fauna. We assume, therefore, that a barrier was raised that shut off connection with European regions during the lower Devonian. The elevation to the south took place somewhere near the close of the Hamilton, and the theory we propose is that an elevation such as to divert the currents, bringing in first the Cuboides fauna from the northwest and finally replacing entirely the Hamilton by the Chemung as far east as New York is the reasonable explanation of the facts.

The interesting point is that the testimony of the migrating fauna chronologically agrees with the testimony of the oscillation, as recorded in the deposits.

All along the southern limits of Devonian exposures in the United States there is indication of an oscillation upward and then downward between the Hamilton and the beginning of the Carboniferous.

The succession of faunas in New York indicates a change at the close of the Hamilton from a fauna whose closest affinities were with the South American faunas, to a fauna whose earlier stages were seen in Iowa, Nevada and the Mackenzie river, and whose affinities were with the Asiatic and European Devonian.

In Arkansas and Tennessee the faunas of the Black Shale indicate that the first marine fauna to appear after the elevation and erosion are of an age as late as the Cleveland shale of Ohio, *i. e.*, the very terminal parts of the Devonian or beginning of the Carboniferous. This event, it will be noticed, is associated with that general elevation of the continent, beginning in the northeast, which is expressed by the cessation of marine faunas, and terminating in the Coal Measures and the final elevation above the surface of the great mass of the continent east of the Mississippi river.

This illustrates the general law of the close relationship between the fossil faunas and their environment.

Just as the geologist knows how to interpret the fineness or coarseness of sediments into relative distances from a shore line, so the paleontologist is able to see in the shifting of faunas and the comparison of species evidences of elevation or depression of the marine bottom, which upon reaching sea level produced often the diversion of ocean currents and consequent modification of faunas. By the comparison of extinct faunas he learns to recognize the continuity or the discontinuity of the conditions of environment such as mark geographical areas of distribution of living animals. The fossil faunas, their modifications and their migrations, as indicated by presence, absence, rarity, abundance, size, variation, or mutation of their species, are the sensitive evidences of changing geological conditions upon which the geologist must depend for tying together his disconnected facts. Fossils have too often been regarded as only marks for distinguishing the different geological formations, but the scope of the paleontology of to-day is far wider. The modern conception of the evolution of life has made paleontology the science of the *History of Organisms.* And it is because fossils exhibit in morphological characters the evidence of the ancestry through which they have arisen, and of the conditions of environment through which they have successfully struggled, that they are of such paramount value in all geological investigations in which the elements of time or the order of sequence of events is concerned.

SOME PROBLEMS OF THE MESABI IRON ORE.*

N. H. Winchell, Minneapolis.

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*Read, August 22, 1892, before Section E, of the American Association for the Advancement of Science, Rochester, N. Y.

3. It is overlain by or results from change in taconyte.
4. It is at or near the horizon at which the great gabbro disturbance is believed to have occurred.
5. It is associated with much kaolin or stratified sedimentary kaolinic rock.
6. At the same horizon is an important ore stratum the whole length of the range—at least 150 miles in Minnesota.
7. In the near vicinity of the gabbro invasion the ore is hardened and largely converted to magnetite.
8. It exists also as an important ore horizon further south, and beneath 480 feet of black slates, having been struck by diamond drill. Similar facts are reported from Menominee, Mich.
9. The whole ore bed is sometimes an original breccia, and at times some of the associated rock strata consist of coarse breccias and of conglomerates.
10. No theory yet proposed for this ore is wholly acceptable.
11. If the assignment of the date of the gabbro to this horizon be fully established, it would furnish a *causa vera* for some of the physical features, and would suggest an intimate relation between the ore and the gabbro.

Perhaps there is no more important or more interesting question, at present debated, relating to the iron ores of the Northwest, than that of their origin and their stratigraphic relations. From an economic standpoint, no less than from a scientific, there could be no more important question, for it is not until the geological relations and origin of these ores are understood that proper methods of mining them can be entered upon, and with the least expense. It is because of recent studies in the field, adding some new facts to the solution of this problem, or complicating it by the injection of some new conditions, that the writer desires to review the elements of the problem and to show the difficulties that yet lie in the way. It will be well to enumerate briefly the hypotheses that have been propounded recently, as an introduction to this discussion. There are five.

1. *Substitution for limestone.* Microscopic examination revealed the existence of remnants of calcite, or dolomite, in some of the "cherts" accompanying these ores in some places, and after long research the late professor Irving arrived at the conclusion that the whole body of the ore horizon was originally in the form of a limestone essentially, a "cherty carbonate," simulating in origin and essential characters, the black-band ores of the Carboniferous. This inferentially led to the idea of a great primordial carboniferous age.

2. *Substitution for carbonate of iron.* Owing to the frequency of such a change observed in nature, it was but a short step to suggest a carbonate of iron instead of a carbonate of lime. This would more readily supply the iron, which must be explained, than carbonate of lime, and at the same time would only require a slight change, if any, in the nature of the original rock, and in the conditions of its deposition.

3. *Concentration of iron oxide from the decay of ferriferous*

schists, or other rock. When rocks decay, it makes but little difference what they are, they part with their contained iron. It may go off in solution, if the proper acids be present, and be gathered as oxide under ordinary natural drainage and weathering. in considerable quantities. on the evaporation of the solvent at some lower level. This process has been suggested as the possible cause of the accumulation of these ores at the stratigraphic horizon where they occur.

4. *Accumulation in troughs formed by dykes cutting tilted strata at a somewhat uniform inclination*, the iron itself being supposed to have been carried down and deposited by ferriferous waters, replacing a supposed "cherty carbonate." This hypothesis involves the same conditions and processes as No. 1 above, but also gives explanation of the location of the supposed ore lenses. At the same time it involves the decay and concentration in a definite rock horizon which is demanded by No. 3.

5. *Deposition from oceanic solution at the time of the formation of the rocks associated.* That the iron ores of the Keewatin age were deposited from solution, has been inferred from their association with rocks whose composition requires the cotemporaneous action of eruptive forces—but which are stratified by oceanic agency—such eruptive action causing chemical reactions that would result in the precipitation of iron and silica. This hypothesis has been applied by the writer also to a portion of the Mesabi ores, viz., such as are embraced as somewhat irregular (wandering) strata in the lower portion of the formation. Such may be either hematite or magnetite. It may perhaps be extended farther than has been proposed.

Some facts of the manner of occurrence.

The Mesabi iron range extends, within the limits of Minnesota, a known distance of more than 150 miles, and it is iron-bearing through its whole extent. It commences at the west end of Gunflint lake, on the national boundary, and has been partially explored southwestwardly as far as the Mississippi river near the falls of Pokegama. The iron horizons do not fluctuate in their stratigraphic positions. The iron varies as the character of the accompanying rock varies. It is a duplex range and embraces ores of two distinct origins and kinds.

The more southerly portion of the range, which is made up of gabbro hills, contains large deposits of titanic magnetite, and this may be dismissed with the statement that this ore is at present not used, and of little economic concern. This discussion appertains wholly to the more northern belt where the recent remarkable developments have been made. This northern belt embraces non-titanic magnetite and hematite as well as limonite and gœthite, or "yellow ochre," as it is sometimes denominated by the miners. The magnetite thus far discovered is not of economic importance, compared with the hematite and gœthite, but there are explorations now being made in some of the magnetites which promise to become perhaps equally valuable with the hematites.

The non-titanic magnetite is found in the eastern portion of the range and at a lower horizon in the strata than the hematites, and when it is represented in considerable amount there is little or no hematite in commercial quantities. It is sometimes in close association with the gabbro containing titanic magnetite, and it is a reasonable hypothesis to refer the magnetic quality to the effect of the heated gabbro on the original ore, concentrating the iron by the expulsion of some of the oxygen. Still there is a trace of magnetic ore further west. It is there found in lean iron-bearing rock, and occupies belts of a few inches which pass through the rock in a rather peculiar zigzag or wandering fashion. But still further west the Pewabic quartzyte, which is the horizon which holds the magnetite in the eastern end of the range, is again regularly interstratified with magnetite in considerable amount, and as such it has been explored for commercial uses.

Hard hematite is found in the Mesabi range, but it is rather as an accidental appendage of the soft hematite, and usually it grades into low-grade ore and is discarded.

Hard limonite is found in larger quantities than hard hematite. It is apt to be impure, and it occurs in somewhat the same manner as the magnetite—*i. e.*, it branches and permeates a rock bed irregularly, though frequently seen in distinct nodules and in vugs when it is found to be a valuable ore.

The hydrated oxide, however, in the form of gœthite is quite abundant. Some shipping mines will depend largely on this ore. The ore is in the form of ochre-yellow powder, or small masses easily reduced to powder. It is found only in the region of the recent new developments, in the western portion of the range.

Soft hematite, however, is the ore for which the "Range" will be celebrated. This has recently been discovered in indefinite and almost incalculable amounts. It is generally amorphous, but in lumps, frequently as if a breccia of some sedimentary rock, easily crushed, and it also exists as a granular powder, finer than mustard seed, and can be mined by the simplest methods. The plans now being entered upon for excavating it only require a steam shovel and a railroad train.

Stratigraphic relations.

The horizon in which this ore occurs is that which has been identified as Taconic, or primordial. The strata have a gentle dip toward lake Superior, and a uniform strike from one end of the range to the other. The strata are as follows in descending order, omitting minor variations.

1. Black slate with interbedded sheets of eruptive materials which are widespread and non-amygdaloidal.

2. Gabbro out-break. Titanic ore horizon. The line of this outbreak is found not to follow the present northern strike of the hematite ore horizon, but to encroach upon it, giving hard ores in the eastern end of the range, while toward the west its line of outbreak turns more southerly, passing the head of lake Superior at Duluth, but apparently forming a bed of conglomerate and breccia along the ore belt, noted at various places between Gunflint lake and Pokegama falls.

3. A peculiar siliceous rock, partly jasperoidal, partly of hard hematite, or hard limonite, sometimes conglomeritic and brecciated, cherty, flinty, usually gray, sometimes partly black or purple, and, toward the west, kaolinic, toward the east holding some magnetite. Altogether this is a non-descript rock, which sometimes is fifty feet in thickness, but so far as developed near the mines is less than twenty. It is a pretty constant rock and when the ore is absent it lies on or varies to the Pewabic quartzyte. This is the horizon of the hard hematite, hard limonite and of some of the non-titanic magnetite. In some way not yet fully determined it is associated with the next. It is not yet certain that all the soft ore is derived from a change of this rock to ore, but it is very certain that in some cases this rock is converted to ore. It overlies, apparently, the chief ore body of the range, or its lower portion is changed to ore.

4. The chief horizon of soft hematite. The greatest thickness this bed has yet been found to exhibit is 105 feet. In the midst

of this ore are found sometimes irregular masses of rock like No. 3, as if remnants of that stratum not yet converted to ore, while some strata of soft ore are found also in the midst of No. 3. Not enough working has been done yet to reveal all the relations of the ore to No. 3.

5. Pewabic quartzyte. In the near vicinity of the gabbro foci this is remarkably modified. Originally probably a chemical oceanic precipitate in its upper portion it is consolidated to a vitreous quartzyte, but at more distant points it is composed of distinct rounded grains. The upper portion is in the form of chalcedonic silica (so-called), a phase which extends westward, with modifications, so far as observed, at least to town 60-13. On the other hand this quartzyte becomes less siliceous, having a feldspathic element, and even an olivinitic constituent, and sometimes large hornblende crystals embrace the quartz grains in a common matrix. When olivinitic it is also magnetitic and constitutes an important iron ore. In some places farther west, near the Mississippi river, is a quartzyte which is evidently the same, regularly interbedded with magnetite in thin alternations.

6. Conglomerate. This is simply the base of the quartzyte, and takes on the character of the older underlying rock. When it lies on the greenstones its cementing matrix is green, when on the granite it is more siliceous and lighter.

Northward from the strike of these strata extends the Archæan complex, embracing the rocks and ores of the Vermilion range and the foregoing beds lie unconformably on the upturned edges of the older rocks where the two formations come into contact. But, wherever the highland spurs of the older rocks extend further southward, the primordial strata sweep about their bases, dipping in opposite directions on opposite sides of the spurs. They occupy no constant level, which might be considered an oceanic shore line, but they seem to exist where erosive agents have not been able to remove them. Hence they may have extended formerly much further north. It happens, however, that a range of granitic hills, the Giant's range, occurs but a short distance to the north, and sometimes the strike of the Taconic is coincident for some miles with the southern base of this range. In other places a belt of "greenstone," which, however, is itself rather rough and rises nearly as high as the granite hills, intervenes between the Taconic and the granite.

It is evident that the present surface contour is but a poor guide to the stratigraphist in attempting to determine the relative ages of these terranes, for the surface must have suffered a profound degradation. The gabbro rock, which is by all conceded to be an irruptive rock, shows no sign of ever having outflowed at the surface of the earth. It is not bedded by amygdaloidal partings, nor has it, so far as known, any variable texture due to contacting with other older rocks. Yet it comes into contact with various older terranes, having crowded backward upon them while yet confined within the crust of the earth, without reaching the surface. It has been seen overlying the Pewabic quartzyte, the Keewatin greenstone and the granitic rocks of the Giant's range, but maintaining everywhere a coarse and crystalline texture. It seems as if the irruptive movement must have been very slow, and that it progressed not forcibly, but as rapidly as the heating of the adjacent rocks rendered them more flexible. Subsequent to the molten invasion the surface degradation took place revealing the deep-seated contacts which we see. It has been the writer's opinion that this event of the irruption of the gabbro took place immediately after the deposition of the Pewabic quartzyte, based on the interbedding of that quartzyte with a rock resembling the gabbro, and on the observed immediate overlie of the gabbro on an extensive area of the quartzyte. This observed overlie, however, loses its importance when it is learned that the gabbro also overlies the Keewatin and the crystalline granite of the Giant's range, and the date of the disturbance will have to remain, as heretofore, not definitely established.

In further considering, however, the Mesabi iron ore, certain problematic difficulties appear in the way of accepting any of the proposed theories for the origin of the ore. These may be enumerated:

1. There is no limestone known in the region, which could be considered the parent rock giving rise to this ore by a process of substitution, nor has there been any struck by any of the diamond drills that have recently been driven through the ore horizon.

2. There is no known horizon of spathic iron which can be considered to have been converted to oxide.

3. There is no dissemination of carbonate of lime in the form of calcite, such as to indicate that the ore may have resulted from a substitution of iron for lime. The sparse mingling of minute fragments of calcite crystals, in microscopic sizes, with the silica

of the chert, in some of the less ferruginous parts of the formation, is hardly sufficient to account for such a vast deposit of iron ore. It seems like trifling with the problem to appeal to such a cause for the ore.

4. As to concentration by decay of ferruginous schists--the process seems to have been the reverse, viz., from the ore has been diffused iron oxide through non-ferruginous schists, so that for several feet from the ore the surrounding rock is stained a vermilion or brownish red. This has not only affected some of the green schists, but also some of the underlying quartzyte. And again, on the theory of ferruginous concentration from schists, or from any rock, it is necessary to explain the singular fact—singular under that hypothesis—of the occurrence of the ore always at the same stratigraphic horizon in the same formation. Why should not this ore accumulate, at least sporadically, at some lower or slightly higher stratigraphic horizon? Here we find it, for 150 miles, maintaining its position in the series as constantly as any of the beds that are associated with it.

5. The absence of dykes of irruptive rock. These have been supposed to have played an important role in the concentration of the hematites of the Penokee range, on the south side of lake Superior. Yet, on the north side but one such dyke has been discovered, and that is in the eastern extension of the iron range where, notwithstanding a year's costly exploration in the vicinity, no hematite has yet been found in commercial quantities. At the western end of the range, where the recent discoveries have been made, not a single dyke has been discovered. Further, the strata that enclose the ore are not impervious, and could not form troughs, by any combination of dyke and dip, but the underlying rock is a loose white sandstone. It has sometimes become deeply stained by the downward percolation of surface waters carrying the ore mechanically amongst its rounded grains.

6. There is an apparent extensive change in the rock of the country. The details of this change cannot be given here. As one stands at the brink of one of the excavations and sees distinctly a sweep of plainly originally sedimentary layers, across the face of the cut, manifesting all the usual characters of sedimentation, and reflects that the strata which he now beholds consist of bessemer hematite, slightly brecciated, soft, easily mashed, he is driven to one of two conclusions—either, first, that the ore was deposited as a constituent part of a sedimentary series, or second,

that it is the result of some grand substitution process by which hematite has been made to take the place of the original sediments. There are besides numerous minor evidences of some transition in the rock from its original composition to hematite, viz.:

(a) Sometimes a gradual encroachment of a hematitic coloration from the outer portions of a block, or layer, upon a gray or blue central area.

(b) Sudden cessation of a band of hematitic coloration at a fissure which evidently the waters producing the coloration could not pass, and the passage of the same waters, as shown by the narrow streak of hematite in the fissure, down the fissure away from the band before affected, leaving that portion on the other side of the fissure unstained—while at the same time the sedimentary banding of the whole rock sweeps unimpaired across the whole face, from one side of the fissure to the other.

(c) There are larger areas where, as revealed by some of the shallow shafts on the western end of the Mesabi range, there is an abrupt change, horizontally, from rock to ore, the separating line being distinct for a perpendicular distance of at least two feet. In other places in the same shaft the ore and rock encroach irregularly upon each other. In these cases the ore is soft red hematite. If the process of substitution were now going on it would be reasonable to expect the oxide would be hydrated, especially as such transition is within a few feet of the surface and easily accessible by atmospheric waters.

(d) Not only is the rock changed *in situ*, but as breccias and gravels large deposits are found in which the pebbles, rounded as in a river current, or on an ocean beach, are converted to hematite. Such pebbles were rounded while still rock, and were subsequently converted to hematite. This is evinced by the varying texture, and concentric structure which change somewhat regularly from the surface to the centre, the outer crust being dense and the central portions being vesicular. Whether such pebbles appertain to the rocky strata, or are of the age of the drift, has not as yet been determined.

Some necessary postulates.

Notwithstanding it seems inadmissable to adopt any theory proposed thitherto for the origin of this ore, and that we are not qualified to propose a new one, there are some important facts which must be taken into account when the true explanation is discovered. These facts, which are based on observations made partly during the present season, may be set down severally as postulates on which some satisfactory theory may possibly be, in part, built at some future time.

1. The ore has a definite position in the stratification.

2. It is underlain by a porous quartzyte.

3. It is overlain by, or results from a change in a peculiar rock to which we have given the name taconyte. [To be described fully at a later date].

4. The whole ore bed is sometimes a breccia of some sedimentary rock, lying loose, and sometimes compact brecciated or even conglomeritic phases are common. Rarely a pebbly ore is found.

5. It is associated with much kaolinic, but water-stratified rock, and often the white kaolin, though embraced in the ore, is unstained by it.

6. It occurs at the same horizon the whole length of the Mesabi range.

7. When the gabbro of the Mesabi range is adjacent this ore is found to be hard—either hematite or magnetite, but it is never affected by titanic acid—though it is by sulphur under such circumstances.

8. Apparently it runs southward with the dip of the formation, and by boring it is found under a large thickness of black slate about a mile south of the line of strike.

9. The horizon of the ore is the same that has been assigned by the writer to the date of the disturbance of the gabbro flood But as that assignment is not sufficiently established it cannot be said that the ore has any relation of cause and effect to the gabbro.

Conclusion.

There are but two items in the conclusion to which we are driven:

First. The Mesabi ore is not satisfactorily explained by any theory that has yet been proposed for it, or for its equivalent (Gogebic) ore on the south side of the great lake. There are some facts that favor all of the theories that have been proposed, but they meet with opposing facts of greater import.

Second. There is but one known cause acting with sufficient force and on a geographic area sufficiently wide, to which we can appeal for the geographic and stratigraphic distribution of this ore—and that is *oceanic sedimentation.* That there has been a profound change in the sediments since their origination is quite evident; but whether this change took place, in whole or in part, prior to consolidation or after it, is as yet unknown; and if after consolidation it is equally unknown whether it was accomplished in Taconic or in Recent time. There seems to have been something peculiar either in the nature of the sediments of this horizon or in the influences to which they have been subjected, and this peculiarity is expressed on both sides of the lake Superior basin.

EDITORIAL COMMENT.

The United States Geological Survey.

The phenomenal development of the U. S. Geological Survey has received its first serious check. Congress refused to vote the amount of money asked for by the director for its support during the current year, granting only about forty per cent. It became necessary at once to dismiss many of the employés, and even to abolish, or close temporarily, some of the lines of research on which the Survey was engaged. The annual cost of the survey has been for several years, between six and eight hundred thousand dollars, and the men who have been in commission or constant employ, have been about one hundred and fifty, not including laborers.

We do not conceive that this check is indicative of any desire on the part of Congress to put an end to the Geological Survey, although it is well known that a few legislators would welcome that result. We do not even suppose that Congress desired to injure the survey, or to impede it in the construction of the great geological map of the United States. In the hurry of the action taken by Congress in the closing hours of a long session, it is impossible to know what motives actuated the individual congressman, and it was manifestly impossible to express any formulated criticism or to enact any general plan for the future of the survey. The only feasible step was to reduce the annual fund and instruct a committee to report on the survey at its next session. The action taken by congress will be construed by some, and especially by those who are affected by it officially, as a calamity to geological science. In some respects it will affect American geology unfavorably, but it is not by any means certain that true geological science will in the end be retarded by it. The survey may be curtailed in scope, but at the same time it may be given directness and individuality which will carry it triumphantly through future years to an end that will be "simple and entire." Unfortunately, the United States Geological Survey never had any other organic act, nor any other duty assigned it more definitely than to "construct a geological map of the United States." It was left practically to the judgment of the director, who officially reports to the Secretary of the Interior, although he is in no sense subject to his direction, to give significance and scope to that simple clause. It is manifest that there was open a wide door for difference of opinion, and for the expansion of the work of *constructing a map*, so as to include inquiries into the history and philosophy of geology, the physics of mountain structure, the causes of earthquakes, the laws of solids and fluids, the economic statistics of the rocks to be mapped, the description of the fossil contents, the microscopic delineation of the internal structures and the chemical characters of the minerals in the strata concerned. All this, if entered upon, would require a large library and numerous laboratories. It would mean the establishment of a scientific bureau which in its original research would be limited in its ultimate scope only by the bounds of human knowledge and the appropriations of money which Congress might grant. It is quite possible that the zeal of the director for American science in general has led him to take some such a view of the proper duty of the survey, and that under the head of geology he has been induced to include, practically, all that it covers theoretically, and has not sufficient warrant for it in the law ordering the construction of a geological map of the United States. However desirable such a bureau might be, whether as an agent for the advancement of American science, or as a guide to other bureaus or to the state governments, in carrying forward allied investigations, it is open to doubt whether Congress intended to organize one when it created the geological survey. In the uncertainty which must exist on that point, it is plain that any parties or institutions which might become aggrieved, whether through fancied or actual wrong, or who might suppose their prerogatives were being usurped by the geological bureau, would not fail to point out the necessity of some change, and that their united voices, becoming voluminous, should finally find expression in adverse action by Congress.

There are various minor causes that might be appealed to, to explain the refusal of Congress to continue the survey on its present basis. Personal controversies, scientific jealousies, internal dissensions, however cloaked under social and official etiquette, local and state antagonisms, and the scientific ostracism which some have imputed to the survey against those who have criticised it and its work, these may have been, in some instances, the mainsprings which prompted individual opinion and advice, but we think we have compassed the whole opposition, so far as Congress could take cognizance of it, when we attribute the action to the conviction on the part of Congress that the survey had been expanded without warrant, so as to include much costly, original research which the law of the survey does not authorize.

If, in the future, the work of the survey can be confined to a more limited field, so that the geological map may be constructed as rapidly as is consistent with thoroughness, and so that the science of geology may be relieved, financially, from the entanglements of other natural science, unless they be bound to it by statutory definition, we believe the progress of science in America will not be impeded by the adverse action of Congress; but that, on the contrary, numerous efficient laborers will spring up where now there is little encouragement for local effort, and these allied investigations, relegated to independent institutions, scattered in all parts of the United States, will be carried on successfully and with a certain local pride, while the science of geology itself will pursue an unobstructed line of progress.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Two Montana coal fields. By WALTER HARVEY WEED. Bulletin, G. S. A., vol. iii, pp. 301-330, with 13 figures in the text; June 28, 1892. The Great Falls coal field, belonging to the Kootanie formation, of Lower Cretaceous age, is found to occupy a width of a few miles adjoining the northeast base of the easternmost range of the Rocky Mountains, and to extend from the sources of the Judith river in central Montana northwesterly at least 125 miles, and probably onward across the international boundary. Its thickest known coal seam is mined at Sand Coulée, twelve miles south of Great Falls, having a thickness of 3½ to 7 feet of excellent fuel coal. The Kootanie or Great Falls formation of sandstones and shales, with gentle dips, reposes unconformably on the Carboniferous rocks which form the foot-hills, succeeded westward in the mountain ranges by steeply upturned and folded strata ranging in age as determined by fossils, from Carboniferous to Cambrian. Above the Kootanie beds, whose identification here by their flora was first announced by Newberry five years ago, the next recognizable formation is the Ft. Benton, the intervening Dakota formation not being apparently represented The Kootanie flora has many species in common with the Potomac formation.

A smaller coal field, allied by its fossil plants to the Ft. Union beds overlying the true Laramie, is mined at Red Lodge, situated near the south line of Montana on the Rocky fork, tributary to Clarke's fork and the Yellowstone. In this vicinity nineteen coal seams have been examined; and six of them, which have been worked near Red Lodge, vary in thickness from 5 to 13 feet. The strata dip about 15° southward, terminating at the fault line that runs along the northern base of the Beartooth range which, though unexplored, is known to be glacier-crowned and is believed to include the highest peaks in Montana.

Summary Report of the Geological Survey of Canada for the year 1891 ALFRED R. C. SELWYN, Director. Department of the interior, Ottawa. 60 pages; price 5 cents. Among the many fields of work by this survey, all of which are here described, with concise statements of their principal results, the observations of most economic importance relate to a very rich coal field of tae Kootanie formation in the southeast edge of British Columbia, about 200 miles northwest from Great Falls, Montana. Between the eastern summit of the Crow's Nest pass, which crosses the most eastern ranges of the Rocky Mountain belt, and the valley of the Elk river at the mouth of Coal creek, which flows westward from this pass, Dr. Selwyn estimates an area of not less than 144 square miles, containing about 50,000,000 tons of coal in each square mile, of which probably half on an average is available for mining. Twenty coal seams were examined in the Crow's Nest pass and westward, showing a total thickness of 132 feet of coal. Three of these seams are respectively 30, 20, and 15 feet thick. On the eastern side of the Elk river about seven miles below Coal creek, the series has twelve coal seams, three of which are each about 30 feet thick, with an aggregate of 148 feet.

Essayo Estadıshio del Estado de Jalisco, por MARIANO BARCENO, Director del Observatorio Meteorologico Central. (Annales del Ministerode Fomento de la Republica de Mexico, Mexico, 1891. 8vo, pp. 729)

Few, if any of the United States, possess such an excellent official and comprehensive description of their resources as professor Barceno has presented in this admirable monograph on Jalisco, one of the western central states of the republic. The neatly printed volume is divided into nine parts, treating of the geography, orography, geology, hydrography, climatology, flora, agricultur, horticulture, and the acclimatization of plants introduced into the state.

Paleozoic Formations in Southeastern Minnesota. By C. W. HALL and F. W. SARDESON. Bulletin, G. S. A., Vol. III, pp. 331-368, with three plates, and seven figures in the text; June 23, 1892. The maximum total thickness of the Paleozoic strata in this district is about 2,400 feet, their western limit being a line drawn from north to south not far west of Minneapolis and Mankato. The formations classed as Upper Cambrian attain a thickness of nearly 2,000 feet, while the Lower Silurian measures only about 450 feet. No Upper Silurian rocks are found; but a few feet of early Devonian beds occur in the south edge of the state. The Trenton and Galena limestones and shales are subdivided into ten beds, distinguished partly by lithologic but chiefly by paleontologic characters Lists of the fossils observed in each of these beds, and in the other formations below and above the Trenton series, are noted. The authors extend the Cambrian upward to include the Lower Magnesian or Shakopee limestone, which is regarded by Walcott as the base of the Silurian.

Geology of the Taylorville Region of California. By J. S. DILLER. Bulletin, G. S. A., Vol. III, pp. 369-394, with nine figures of sections in the text; July 15, 1892. The area here described is about twelve miles long and six miles wide, lying in the northern part of the Sierra Nevada mountain belt, immediately north of the fortieth parallel. Mt. Jura, near the center of this area, is so named because of its fossiliferous Jurassic rocks. The exposed sedimentary series has a total thickness of 24,500 feet; of which 17,500 feet are probably Paleozoic, and 7,000 feet are Mesozoic strata. The latter comprise at least three formations in the Trias, and five in the Jura, definitely recognized by fossils. Eruptive rocks are also present in great variety, their epochs of extravasation being successively early Paleozoic, Triassic, at the close of the Jurassic, and finally Neocene and Pleistocene. The region was covered by the sea during most of its history, until the end of the Jura period, when a great upheaval formed land along the present Sierra Nevada belt

Jura and Trias at Taylorville, California. By ALPHEUS HYATT. Bulletin, G. S. A., Vol. III, pp. 395-412; July 15, 1892. Professor Hyatt in this paper gives preliminary descriptions and discussion of the rich faunas, of early and middle Mesozoic age, which have been collected in the strata of Mt. Jura and other parts of the area described by Mr. Diller in the preceding paper. The Jurassic formations, in ascending order, are the Hargrave sandstone, referred to the Upper Lias of Europe; the Thompson limestone and Mormon sandstone regarded as equivalent with the inferior Oolite; and the Bicknell sandstone and Hinchman tuff, respectively representing the Callovian and Corallian faunas of the European Upper Jura or Malm. The Jurassic system is more fully recognizable here than in any other known locality in the United States.

The Geological Map of the United States, and the United States Geological Survey. JULUS MARCOU. Cambridge, Mass. April, 1892. 8vo, pp. 56.

This is a caustic review and criticism of the United States Geological Survey, its organization, work, personnel, and its relations to the progress of geology in America. Mr. Marcou's style of direct and severe criticism is a marked characteristic of this pamphlet, and his well-known fearless manner of exposing what he is convinced is wrong, is apparent in every line. His life has been spent as an "independent geologist," and very often his independence has been asserted at cost of his personal advantage.

Mr. Marcou has radical and sometimes impractical views touching the U. S. Geological Survey, but some of his strictures have a basis of just criticism. He thinks the survey has been too costly, especially in publication, and spread over too wide a field. He would have the field-work wholly completed in a district before the geologists publish any of the results, and he would have all reports confined strictly to descriptive facts, without entering into controversy. Precipitate publication entails contradiction and correction, and he would have the work of the survey above possible correction. He questions the capability and sometimes the candor of many of the leading collaborators on the survey, and would have every employé who may be responsible for any geological work, well informed on the geology of the original typical European localities; and when such cannot be found in America, he would have European geologists employed, or would send American geologists to Europe to study for several months the rocks and fossils which first gave name and character to the formations which the separate geologists may be entrusted with in the United States.

This document was freely distributed at Washington, and it was one of the factors to produce the late unfavorable action of congress in refusing the customary appropriation for the survey.

LIST OF RECENT PUBLICATIONS.

I. State and Government Reports.

Geol. Surv. of Penn. The Summary Final Report, Vol. 1, describing the Laurentian, Huronian, Cambrian and Lower Silurian formations, pp. 719. Harrisburg, 1892. Atlas: Southern Anthracite Field: Parts IV B, V and VI, 1891.

Geol. Surv. of N. J. Annual report of the State Geologist for 1891, pp. 270. Trenton, 1892.

Geol. Surv. of Ala. Bulletin No. 2. On the Phosphates and Marls of Alabama, by E. A. Smith, State Geologist, pp. 82. Montgomery, 1892.

Ken. Geol. Surv. Report on the Progress of the Survey for 1890 and 1891, by John R. Proctor, pp. 26 with map. Frankfort, 1892.

U. S. Geol. Surv. Monographs, Vol. XVII. The Flora of the Dakota Group, by Leo Lesquereux, pp. 400. Washington, 1892. 4to.

Eighth Annual Report of the State Geologist of N. Y. for 1888 contains: A classified list of the Palæozoic genera of Brachiopoda, by J. M. Clarke. A list of fossils in the Oriskany sandstone of Maryland, New York and Ontario, Canada, with an indication of their geological range, by Charles Schuchert; The Genus Bronteus in the Chemung rocks of New York, by James Hall; A list of the species constituting the known fauna and flora of the Marcellus epoch in New York state, by J. M. Clarke; The Hercynian Question, by J. M. Clarke; On the locality of flint implements in Wyoming county, N. Y., by I. P. Bishop; A catalogue of the specimens arranged by Prof. E. Emmons, as representatives of the Taconic System.

Ninth Ann. Rep. of the State Geologist of N. Y. for 1889 contains: A notice by Prof. Hall of the slow publication of his palæontological work; On Syringothyris, Winchell, and its American species, by Chas. Schuchert; List of species of the American Palæozoic Orthis, Spirifera, Spiriferina, and Syringothyris, by Chas. Schuchert; New Forms of Dictyospongidæ from the rocks of the Chemung group, by James Hall.

Tenth Annual Report of the State Geologist of N. Y. for 1890 contains: The genera of the Palæozoic Brachiopoda; Preliminary notice of a new Genus among the Brachiopoda, by James Hall; Quaternary Geology of the Hudson River valley, by Heinrich Ries, and the following by J. M. Clarke which were reviewed in the GEOLOGIST for March, 1892: Notes on the Genus Acidaspis, Note on Coronura Aspectans, Conrad (sp.), Observations on the Terataspis Grandis, Hall.

N. Y. St. Museum. Forty-third Annual Report of the Regents for 1889, pp. 306. Albany, 1890.

N. Y. St. Museum. Forty-fourth Annual Report of the Regents for 1890, pp. 404. Albany, 1892.

Geol. Surv. of N. Y. Palæontology: Vol. VIII. The Genera of Palæozoic Brachiopoda, by James Hall, assisted by J. M. Clarke, pp. 367 with 42 plates.

Geol. Surv. of Tex. Bul. No. 2 The Soils and Waters of the Upper Rio Grande and Pecos valleys, by H. H. Harrington, pp. 26, Austin, 1890.

Geol. Surv. of Tex. Bul. No. 3. Reconnoissance of the Guadaloupe mountains, by R. S. Tarr, pp. 42, Austin, 1892.

Geol. Surv. of Tex. Second Report of Progress, by E. T. Dumble for 1891, pp. 91. Austin, 1892.

Geol. Surv. of Ala. Bul. No 3. The lower Gold Belt of Alabama, by Wm. B. Phillips, pp. 97, with map. Montgomery, 1892.

Geol. and Nat. Hist. Surv. of Can. Contributions to Canadian Palæontology. Part IV, by Dr. D. Rüst, pp. 10, with 3 plates.

U. S. Nat. Mus. Handbook for the Dept. of Geology. Part I. Geognosy.—The Materials of the Earth's Crust, by Geo. P. Merrill, pp. 88, with 2 plates. Washington, 1892.

Geol. Surv. of Ark. Ann. Rep. for 1890. Vol. III. Whetstones and the Novaculites of Arkansas, by L. S. Griswold, pp. 443, illustrated. Little Rock, 1892.

II. Proceedings of Scientific Societies.

Bul. Phil. Soc. of Washington, Vol. XI, contains: On Some of the Greater Problems of Physical Geology, by C. E. Dutton; On the Crystallization of Igneous Rocks, by J. P. Iddings; The Mineral Composition and Geological Occurrence of Certain Igneous Rocks in the Yellowstone National Park, by J. P. Iddings; On Certain Peculiar Structural Features in the Foot-Hill Region of the Rocky Mts. near Denver, Colo., by G. H. Eldridge; Constitution and Origin of Spherulites in Acid Eruptive Rocks, by Whitman Cross; Mohawk Lake Beds, by H. W.

Turner; and Spherulitic Crystallization, by J. P. Iddings, which was reviewed in the GEOLOGIST for Dec., 1891.

Trans. N. Y. Acad. Sci., Vol. XI, Nos. 3, 4, 5; Dec., Jan., Feb., 1891-92.

Bul. Am. Geog. Soc., Vol. XXIV, No. 2, June, 1892.

Bul. Geol. Soc. Am., Vol. III—Parts issued:—Palæozoic Formations of southeastern Minnesota, by C. W. Hall and F. W. Sardeson; Geology of the Taylorville Region of California, by J. S. Diller; Jura and Trias at Taylorville, Cal., by Alpheus Hyatt; Stratigraphy and Succession of the Rocks of the Sierra Nevada, of California, by James E. Mills.

Proc. Am. Acad. Arts & Sci., N. S., Vol. XVIII, contains: The Pre-historic and Kiowa Co. Pallasites, by O. W. Huntington.

III. Papers in Scientific Journals.

Geol. Mag., *July No.*, contains: On the Devonian Rocks of S. Devon, by A. R. Hunt (Part II); Notes on the Coniston Limestone, by J. G. Goodchild; Formation of the Boulder-clay, by G. W. Bulman; Glacial Geology, by T. Mellard Reade; A Sand Pit at Hill Morton, near Rugby, by P. B. Brodie.

Aug. No. contains: On the American Palæozoic Gasteropod *Trematonotus*, by R. B. Newton; The Devonian Rocks of S. Devon, by A. R. Hunt (Part III); An Irish Augitite, by Bernard Hobson; Under-clays, A Preliminary Study, by G. W. Bulman; The Black Limestone of Malta, by J. H. Cooke; On *Terebratulina substriata*, by J. F. Walker; Geology of the Lizard District, by A. Somervail.

Am. Jour. Sci, *Aug. No.*, contains: Gold Deposit at Pine Hill, Cal, by W. Lindgren; Great Shearzone near Avalanche lake in the Adirondacks, by J. F. Kemp; Development of the Brachiopoda (Part II), by C. E. Beecher; Preliminary note of a new Meteorite from Kenton Co., Ken., by H. L. Preston; Additional Observations on the Jura-Trias trap of the New Haven Region, by J. D. Dana; Notes on Mesozoic Vertebrate Fossils, by O. C. Marsh.

School of Mines Quart., *July No.*, contains: Methods of Modern Petrography, by L. M. Luquer.

Kansas University Quarterly, Vol. I, No. 1, *July No.*, contains: Kansas Pterodactyls (Part I), by S. W. Williston; Kansas Mosasaurs (Part I), by S. W. Williston and E. C. Case.

IV. Excerpts and Individual Publications.

On the Occurrence of Artesian and other Underground Waters in Texas, eastern New Mexico, and Indian Territory, by Robt. T. Hill. pp. 166. From Rep. Dept. Agr., Washington, 1892.

On the Sponge-remains in the Lower Tertiary Strata, near Oamaru, Otago, New Zealand, by G. J. Hinde and W. M. Holmes. pp. 86, with plates. From Linnean Soc. Jour., Vol. XXIV, London, 1892.

The Thickness of the Devonian and Silurian Rocks of western New York; approximately along the line of the Genesee river, by Chas. S. Prosser. pp. 55, with map. From Proc. Rochester Acad. Sci., Vol. 2, Rochester, 1892.

V. Foreign Publications.

Annual report of Dept. of Mines and Agriculture, New South Wales, for 1891. 4to, pp. 322, with cuts and maps. Mainly devoted to Economics and Statistics. Sydney, 1892.

The Physical Geology of Magnetic island, by A. Gibb Maitland, pp. 8. 4to., with two maps and sections. Brisbane, Queensland.

Bul. Soc. Imp. des Natur. de Moscow, No. 4, 1891, contains: Argiles de Speeton et leurs équivalents, par A. Pavlow et G. W. Lamplugh.

Verhand. Russ.-Kaiser. Mineral. Gesell. St. Petersburg. 2d Series. Vol. XXVIII contains: Symmetrie der Figuren regelmässiger Systeme von E. Fedorow; Ueber die Paramorphosen des Rutils nach Anatas; Ueber die Gattung Stenopora Lonsdale und eine neue Art Stenopora Lahuseni, von G. Romanowsky; Petrographische Notizen, von M. Melnikow; Katalog der Meteoriten-Sammlung, von J. Simaschko; Geologishe Untersuchungen in dem Guberlinsk-Gebirge (vorläufiger Bericht) von F. Lewinson-Lessing; Ueber Pterichtys, von Dr. J. Victor Rohon; Kulibinit petrographische Skizze, von M. Melnikow; Kurze Skizze des geologischen Baues des transcaspischen Gebietes, von J. Mushketow; Astrachanit (Blödit, Simonyit) aus den Salzseen im Astrachanschen Gouvernement, von P. Jeremejew.

Archiv des Vereins der Freunde der Natur. Mecklenburg. II Abtheil., 1891, contains: Silur-Cephalop den der Diluvialgeschiebe, von H, Rüdiger; Foraminiferen und Ostracoden aus der Kreide von Moltzow. von G. Schacko; Sedimenätrgeschiebe von Neubrandenburg, von A. Steusloff.

Ueber den Gegenwärtigen Standpunkt unserer Kenntniss von dem Vorkommen Fossiler Glacialpflanzen, von A. G. Nathorst. Bihang till K. Svenska Vet.-Akad. Handlingar, Stockholm, 1892.

Norges Geologiske Undersögelse. Om dannelse af jernmalmforekomster, af J. H. L. Vogt, pp. 152, with map and cuts. Christiania, 1892.

Norg. Geol. Und. Det nordlige Norges geologi, med bidrag af Dr. Tellef Dahll og O. A. Corneliussen, udgivet af Dr. Hans Reusch. pp. 200, with large map and cuts.

Norg. Geol. Und. Toromyrer inden Kartbladet "Sarpsborgs" Omraade, af G. E. Stangeland. pp. 36, with map and cuts, Christiana, 1892.

Sitzungsb. der Physik-Medic. Soc. in Erlangen, Heft XXIV, 1892, contains: Das Marine Pliocän in Syrien, von A. Blanckhenhorn; Beiträge zur Kenntnis der nutzbaren Mineralien des bayerischen Waldes mit specieller Berucksichtigung des Silberges bei Bodenmais, von J. Thiel.

Bul. Soc. Géol. de France, 3d Series, t. XX, 1891, No. 1, contains: Etage miocène et valeur stratigraphique de *l'Ostrea crassissima* au sud de l'Algérie et de la Tunisie, par P. Thomas; Sur l'existence Jurassique supérieur dans le massif du Grand-Galibier, par M. Kilian; Note sur l'âge de *l'Hippurites corbaricus* des Pyrénées, par J. Roussel; Sur une carte des environs de Barcelone de M. J. Almera, par M. Collot.

Verhand. des naturf. Vereines in Bruon. Band XXIX, 1890, contains: Das südost-mahrische Eruptiv-Gebiet, von J. Klvana; Erster Nachtrag zur pleistocänen Conchylienfauna Mahrens, von A. Rzehak; Ueber die Bahn der am 1 Dec. 1889 bei cacak am Jeliza-Gebirge in Serbien gefallenen Meteoriten, von G. v. Niessl; Ueber die Periheldistanzen und andere

Bahnelement jener Meteoriten, deren Fallerscheinungen mit einiger Sicherheit beobachtet werden kounten, von G. v. Niessl.

Die Höhlen des Harzes und ihre Ausfüllungen, von Dr. J. H. Kloos, pp. 24. From Abh.Ver. für erdk. Magdeburg, 1892.

Note Geologische e Studio Chimico-Petrografico sulla regione Trachitica di Roccastrada, by R. V. Matteucci, pp. 50, with plates. Roma, 1892.

Memoire della R. Accad. delle Sci. dell'Istituto di Bologna, 5th series. Tomo v contains: Zifioidi fossile e il Rostro di Dioplodonte della Farnesina presso Roma, by G. Capellini; Secondo contributo alla conoscenza della microfauna terziaria italiana, by Carlo Fornasini; Nuove ricerche sulla melanoflogite della miniera Giona presso Racalmuto (Sicilia), by L. Bombicci.

CORRESPONDENCE.

Geology at the Meeting of the British Association at Edinburgh.—For the fourth time in its history the B. A. A. S. has met in the northern capitol of the United Kingdom, this time under the presidency of the Director-General of the Geological Survey, Sir Archibald Geikie. The date was unusually early. Thus far the first half of September has been the time of holding this gathering, but an experiment was this year made of placing it one month earlier. Time will show if the experiment was successful or not. Probably the change is at least in part accountable for a rather smaller attendance than might have been expected at so prominent a centre of wealth and learning. Many people at this time are out of town and cannot well alter their time of being absent. The numbers at the four Edinburgh meetings have been as follows:

1834, 1,298.
1850, 1,241.
1871, 2,463.
1892, 2,070.

The smaller number present had of course the result of lessening the amount available in special grants, a matter always to be regretted as this is one of the most effective ways in which the B. A. A. S. aids the work of investigation. However, a total of £1,000 was distributed among workers in the various sections. In geology the following sums were allotted:

Prof. J. Prestwich,	Erratic Blocks	£10
Rev. T. Wiltshire,	Fossil Phyllopoda	£ 5
Prof. J. Geikie,	Geological Photographs	£10
Prof. E. Hull,	Underground Waters	£ 5
Mr. J. Horne,	Shell-deposits at Chapel-hall, &c.	£20
Dr. R. H. Traquair,	Eurypterids of the Pentlands	£10

Sir A. Geikie took for the subject of his address, "The Centenary of Hutton's Theory of the Earth." He showed in the course of his remarks how much of our present geological systems was embodied in the "Theory" of this early writer, and how it has survived to the present day, after encountering assault after assault from various quarters.

"It was," he said, "a special characteristic of this philosophical system that it sought in the changes now in progress on the earth's surface an explanation of those which occurred in ancient times. Its founder refused to invent causes or modes of operation, for those with which he was familiar seemed to him adequate to solve the problems with which he attempted to deal. Nowhere was the profoundness of his insight more astonishing than in the clear, definite way in which he proclaimed and reiterated his doctrine that every part of the surface of the continents, from mountain-top to sea-shore, is continually undergoing decay, and is thus slowly travelling to the sea. He saw that no sooner will the sea-floor be elevated into new land than it must necessarily become a prey to this universal and unceasing degradation. He perceived that as the transport of disintegrated material is carried on chiefly by running water, rivers must slowly dig out for themselves the channels in which they flow, and thus that a system of valleys radiating from the water-parting of a country must necessarily result from the descent of the streams from the mountain crests to the sea. He discerned that this ceaseless and wide spreading decay would eventually lead to the entire demolition of the dry land, but he contended that from time to time this catastrophe is prevented by the operation of the underground forces, whereby new continents are upheaved from the bed of the ocean."

"But despite his firm grasp of general principles and his mastery of the minutest details, he had acquired a literary style which was singularly unattractive. Fortunately for his fame as well as for the cause of science, his devoted friend and disciple, Playfair, at once set himself to draw up an exposition of Hutton's views. After five years of labor on this task, there appeared the classic 'Illustrations of the Huttonian Theory,' a work which for luminous treatment and graceful diction stands still without a rival in English geological literature."

Sir A. Geikie then rapidly reviewed the progress of these new opinions and sketched the various objections, scientific and theological, which they had met, passing on to the experimental work of Sir James Hall, and the stratigraphical investigations of William Smith, the "father of British Stratigraphy," and dwelling, as was seemly and courteous, on the great share that Edinburgh and Scotland had taken in the progress of the new science. Passing rapidly over the long and bitter conflict between the Plutonists and the Neptunists, which was mainly waged in the north, he proceeded to the discussion of what may be regarded as the central scientific subject of his address—Uniformity versus Catastrophe. "Though," he said, "Hutton and Playfair believed in periodical catastrophes, and indeed required these in order to renew and preserve the habitable condition of our planet, their successors gradually came to view with repugnance any appeal to abnormal and especially to violent manifestations of terrestrial vigor, and even persuaded themselves that such slow and comparatively gentle action as had been witnessed by man could alone be recognized in the evidence from which geological history must be compiled. Well do I remember in my own boyhood what a cardinal article of faith this prepossession had become

We were taught by our great and honored master, Lyell, to believe implicitly in gentle and uniform operations, extended over indefinite periods of time, though possibly some with the zeal of partisans carried this belief to an extreme which Lyell himself did not approve. What the more extreme members of the uniformitarian school failed to perceive was the absence of all evidence that terrestrial catastrophes, even on a collossal scale, might not be a part of the present economy of this globe. Yet the admission that they have played a part in geological history may be freely made without impairing the real value of the Huttonian doctrine."

The speaker then quoted the Ice-Age as a strong case in point of the truth of his remark. "If," he said, "any one had ventured sixty years ago to affirm that at no very distant date the snows and glaciers of the Arctic regions had descended southwards into France, he would have been treated as a visionary theorist. There cannot, however, be any doubt that after man had become a denizen of the earth a great physical change came over the northern hemisphere. The climate which had previously been so mild that evergreen trees flourished within ten or twelve degrees of the pole, became so severe that vast sheets of snow and ice covered the north of Europe and crept southward beyond the south coast of Ireland almost as far as the southern shore of England, and across the Baltic into France and Germany. Such a marvelous transformation in climate, in scenery, in vegetation and in inhabitants, within what was after all a brief portion of geological time, is surely entitled to rank as a catastrophe in the history of the globe. And yet it arrived manifestly as a part of the great order of nature. And thus taking a broad view of the whole subject, we recognize the catastrophe, while at the same time we see in its progress the operation of those same natural causes which we know to be integral parts of the machinery whereby the surface of the earth is continually transformed."

Passing on then to another doctrine first clearly and definitely stated by Hutton, Sir A. Geikie sketched the views that prevail regarding geological time. "Some 6,000 years had previously been believed to comprise the whole life of the planet, and indeed of the entire universe. But the progress of research continually furnished additional evidence of the enormous duration of the ages that preceded the coming of man, while, as knowledge increased, periods that were thought to have followed each other consecutively were found to have been separated by prolonged intervals. Thus the idea arose and gained universal acceptance, that just as no boundary could be set to the astronomer in his free range through space, so the whole of by-gone eternity lay open to the requirements of the geologist. It was Lord Kelvin who first called attention to the fundamentally erroneous nature of these conceptions. He pointed out that from the high internal temperature of our globe, increasing inward as it does, and from the rate of loss of its heat, a limit may be fixed to the planet's antiquity. He estimated that the surface of the globe could not have consolidated less than twenty million years ago nor more than four hundred million years ago, and he was inclined to believe that, from a review of all the evidence then available, some such period as one hundred million years would embrace the whole of geological history."

"Moralizing on these results," the speaker added, "it is not pleasant to discover that a fortune, which one has unconcernedly believed to be ample, has somehow taken to itself wings and disappeared. When the geologist was suddenly awakened by the energetic warning of the physicist it was but natural that he should think the accountant to be mistaken. But he consoled himself with the reflection that, after all, one hundred million years was a tolerably ample period of time, and might possibly have been quite sufficient for the long sequence of events recorded in the crust of the earth. But further considerations have led to sweeping reductions of the time allowable for the evolution of the planet. Lord Kelvin is willing, I believe, to grant us some twenty million years, but Prof. Tait would have us content with less than ten millions."

Discussing then the argument of the geologists from denudation of the land, he said that the rate of this process had in some cases been determined, and found to vary between one foot in 730 years and one foot in 6,800 years. Assuming the stratified masses to have at their greatest development a thickness of 100,000 feet, "they would require at the most rapid recorded rate of denudation a period of 73 million years, and at the slowest not less than 680 millions."

Alluding then to the biological evidence of great length of time, as shown by the changes which the life of the world has undergone, the speaker gave it as his opinion that the "geological record furnishes a mass of evidence which no arguments from other departments of Nature can explain away, in favor of an allowance of time much beyond the narrow limits which recent physical speculation would concede," and concluded his address with an eloquent and picturesque sketch of the story revealed by geology concerning the region surrounding the ancient capital in which the meeting was held.

Dr. C. Lapworth, the president of the geological section, being ill, his address was postponed and his place filled by various members. Prof. Rupert Jones supplied the vacancy on the first day. The papers were not of special interest, but included one on the Eurypterids of the Silurian rocks, by Mr. Laurie; Prof. Jones' report on fossil phyllopods; the exhibition of perhaps the oldest palæolith yet found, by Mr. Bell and Prof. Bonney; a note on the discovery of the bones of a sperm-whale in Scotland; one by Capt. Paterson; one by Dr. Johnston-Lavis on a pisolicic tuff in the Pentlands, and one by Mr. Watts on lava and ashes in the carboniferous rocks in Ireland.

On Thursday morning, with Prof. Bonney in the chair, the report of the photographic committee was received, and a standard size and mount, to be determined later, resolved on. The report of the boulder committee followed, also that of the underground water committee. Two or three papers were also read on the Ice-age, which, however, contained no new matter, and are chiefly significant as indicating the extent to which the theory of Dr. Croll is losing ground, even in Scotland, the native land, and in Edinburgh the home of its distinguished author.

On Friday the president was sufficiently recovered to be present. The only papers of more than local interest were one by Mr. B. N. Peach on a wide-spread radiolarian chert formation of Arenig age in the Southern Uplands of Scotland, indicating deep sea at the time of its deposit, and one by Mr. D. Bell on "Some alleged proofs of submergence in Scotland during the Glacial Era."

On Saturday, with Prof. Lebour in the chair, prof. Hull gave an account of a recent visit of exploration to Palestine, in which he mentioned that terraces exist, showing that the Dead sea was once filled up to the level of the Mediterranean, now 1300 feet above it, and that in the glacial era, the Jordan formed a lake 200 miles long, while there existed at its northern extremity a volcano sending down streams of lava to the lake of Tiberias.

Dr. Johnston-Lavis presented the annual report on Vesuvius, and one on the exploration of the Elbolton Cave completed the proceedings of the morning.

In the afternoon 960 members of the Association took part in 16 excursions. One of these, to the land of Scott, was rendered remarkable by a visit to Gattenside House, where is now residing Lady Brewster, whose husband, Sir David Brewster, delivered the first annual address before the Association, 60 years ago. Other places of interest seen on this and different excursions were, Abbotsford, Melrose and Dryburgh Abbeys, Leith Docks and the Forth Bridge, Tantallon Castle, N. Berwick cliffs, the Clyde shipbuilding yards at Glasgow, and the oil-works and mines, the Pentland Hills and collieries in their vicinity, and other spots especially interesting to the botanists and zoologists.

On Monday, with Sir A. Geikie in the chair, Prof. Lapworth delivered his address. He dealt mainly with the subject of the general form of the lithosphere, and likened the crust to a series of waves of different lengths and amplitudes, but it was of a nature that does not allow of condensation, and the papers that followed were chiefly of local importance.

The chief disappointment experienced was apparently caused by the unexplained absence of Prof. Garner and a promised paper on "The Language of Monkeys." Possibly the author, as was the case at the A. A. A. S. some years ago, failed to appear on account of insufficient acquaintance with his subject.

Dr. Burdon Sanderson was appointed president for the meeting at Nottingham in 1893, and the date was set for Wednesday, Sept. 13. It may be inferred from this action that the early date chosen this year has been found unsuitable.

A deputation from Oxford presented an invitation, which was accepted, to meet in that city in 1894. E. W. CLAYPOLE.

Akron, O., Aug. 28, 1892.

PERSONAL AND SCIENTIFIC NEWS.

The Geological Society of America held its summer session at Rochester, N. Y., on Monday and Tuesday, Aug. 15 and 16, 1892. The president, Mr. G. K. Gilbert, presided. The first paper, by Mr. Lawrence Johnson, treated of the phosphate beds of Florida and their geological history. In his opinion Florida began by the rise of a number of small islands of Eocene rocks in a shallow Miocene sea, and on these rocky islands, guano was deposited by birds, while marl beds were at the same time formed in the narrow channels. He attributed the origin of the "pebble phosphate" to the disintegration of these Miocene marl beds after elevation. After alluding to the vast erosion which these rocks have suffered, the author divided the phosphate beds into four groups, successively formed:

(*a*) "Compact Rock," phosphate,
(*b*) passing into "Laminated Rock,"
(*c*) then into "Plate Rock," and
(*d*) lastly into "Soft-Phosphate."

In the absence of the author little discussion was possible, but some objection was raised against the origin attributed to the phosphates, inasmuch as the fossil remains indicate marine condition and exuviæ rather than terrestrial.

The next paper, Prof. E. W. Claypole's, on the Dentition of Titanichthys and its allies, after paying a high tribute to the skill and pains of Dr. Newberry in so ably interpreting the first remains of the kind that came to light from the Ohio Devonian strata, and expressing the regret of the society that ill-health detained him from the meeting and from the prosecution of the work, described the detention of the Dinichthyidæ as already known, pointing out the peculiarities of the teeth of the different genera, and then brought forward some recent discoveries by Dr. Clark of Berea, which led to the belief that at least two intermandibular plates or teeth existed in some or in all the forms, and whose presence explained or removed several difficulties that previously presented themselves. One intermaxillary, scalpri-form tooth was also present in the upper jaw, between the two great "pre-maxillaries" of Newberry, which apparently worked against the two already mentioned, in the lower jaw. These additions considerably simplify the mechanics of the jaws of these monsters.

Prof. C. H. Hitchcock followed with a paper on the Connecticut valley glacier. He quoted several cases in which striæ from the north crossed others previously made from 30° west of north, and stated that the latter, in such cases, occupied a slight hollow at the bottom of a basin or trough. He thought that this indicated a change in the direction of the ice and that during the greatest extension of the glacier, when drainage was almost impossible below it, the ice moved over the whole surface in one direction, scoring hill and valley alike, but that in the later stages where local conditions could in part control or influence the drainage, the course of the ice was also influenced thereby and it took its course along the valleys, scoring them in the direction of their length. He also showed a large map of the Connecticut valley glacier on which was represented the long eskar skirting the river and through which its channel has in some places been cut. The stones in the eskar have, he said, all come down the valley, and belong to the region.

A paper by Prof. G. C. Broadhead was then read by Prof. Branner on the Ozark uplift and the history of the palæozoic in Missouri. The author sketched what was, in his view, the course of events during palæozoic time in these mountains, narrating the story of their upheaval and subsidence in the palæozoic sea. The paper was a summary of present knowledge on the subject rather than a contribution of new material.

The paper that attracted most interest was by Prof. James Hall, of Albany, on the "Oneota Sandstone." He showed a section in which the relative position of this disputed layer and its associated strata was set forth, and explained their relationships. The venerable and veteran American palæontologist stated as the result of his long and repeated observations that the "Oneota Sandstone" passed eastwardly into the lower Catskill and westwardly into the Portage. Over the latter lies the Chemung thickening and to the westward, with this thickening comes in a difference of composition, the sandstones of the east giving place to the shales of the west. All these overlie immediately the Tully limestone where this latter exists. Dr. Hall continued his description of the Catskill, stating that no marine fossils existed in it, and that its almost sole bivalve shell and its large fish indicated rather estuarian, or fresh water, than marine conditions of deposit. The merging of the Catskill, lithologically, in the Portage, to the westward is very significant in indicating that the fauna of a group depends not a little on biological conditions, which are second only to secular changes and extinction of species.

A paper on dynamical geology by Mr. Becker was read in his absence by Prof. R. T. Woodward. It dealt with the subject of strains produced by stresses, and insisted on the exact definition of these and several other terms frequently employed with considerable laxity. The paper contained some new views of faulting which called forth a few remarks, but in the absence of the author a paper so mathematical in its treatment could not be fully discussed.

Mr. Warren Upham had a lengthy paper on the structure of the drumlins of Massachusetts. After alluding to similar objects in other parts of the country, he spoke of the different kinds of drift—englacial, subglacial and super-glacial, and maintained that drumlins had been deposited very near the outer edge of the glacial sheet and were caused by acceleration of the upper layers of ice, causing, he said, deposition of material in the form of an oblong hillock at that place. To the longer ridges or eskers he assigned an origin in the beds of the super-glacial streams where gravel was dropped, and this, by gradual settling, at length came to rest on the bed of the glacier.

Prof. G. F. Wright criticised some of the results published by Messrs. McGee and Salisbury from Pennsylvania, and summarized the indications of submergence during the Columbian era, in the Susquehanna valley mentioning terraces rising to a hight of 130 feet above the river at Harrisburgh with others at a lower level. He went over the subject in detail tracing the "fringe," as it has been called, into New Jersey, and maintaining that in some cases decomposed gneissoid rock had been mistaken for northern drift, especially as stones bearing the marks of creep-striæ are abundant in several places. This paper called forth considerable controversy, the extreme views of some on the age of the early drift being actively contested by others.

Some phases in the metamorphism of the schists in southeastern Berkshire, Massachusetts, was read by Mr. W. H. Hobbs and illustrated by photographs of microscopic sections. One by Mr. David White showed a new form of Tæniopteris or an allied form from the Coal Measures, and illustrated the affinity of the genus, and Mr. A. S. Tiffany gave a few interesting facts regarding the excavation of the palæozoic strata in Iowa by very ancient cataracts. Some of that may become of considerable importance in connection with the subject of interglacial drainage.

The council received a cordial invitation from the Royal Society of Canada and the Geological Survey to attend its winter meeting at Ottawa, which was accepted.

At the late meeting of the American Association for the Advancement of Science, Prof. Jos. LeConte, of California, presided over the Association, and Prof. H. S. Williams, of Ithaca, N. Y., over Section E. The meeting was attended by the usual excursions, receptions and other social diversions. About 500 members attended. The next meeting will be at Madison, Wis. Following is a list of papers read in Sec. E. Mr. G. K. Gilbert also gave a public address under the auspices of the Rochester Academy of Sciences, on "Coon Butte and the theories of its origin," illustrated by lantern views.

Terminal moraines in New England. By C. H. Hitchcock.

A Passage in the History of the Cuyahoga river. By E. W. Claypole.

Notes bearing upon the changes of the pre-glacial drainage of western Illinois and eastern Iowa. By Frank Leverett.

Extra-morainic drift in New Jersey. By A. A, Wright.

The volcanic craters of the United States. By Rob't T. Hill.

Recent geological explorations in Mexico. By Rob't T. Hill.

Paleobotany of the Yellow Gravel at Bridgeton, N. J. By Arthur Hollick.

Presentation of samples from the salt mines of New York. By S. A. Lattimore.

The mining, metallurgical, geological and mineralogical exhibits to be shown at the World's Columbian Exposition. By Geo. F. Kunz.

Cerro-Viejo and its cones of volcanic ejecta and extrusion in Nicaragua. By John Crawford.

Paleobotany of the Yellow Gravel at Bridgeton, N. J. By Arthur Hollick.

Pleistocene geography. By W. J. McGee.

Distribution of the LaFayette formation. By W. J. McGee.

Submarine valleys on Continental slopes. By Warren Upham.

Cenozoic beds of the Staked Plains of Texas. By E. D. Cope.

The Homotaxic relations of the North American Lower Cretaceous. By Robt. T. Hill.

Exhibitions of Guelph fossils found in Rochester, N. Y. By Albert L. Arey.

The American Mastodon in Florida. By John Kost.

Some problems of the Mesabi iron ore. By N. H. Winchell.

The mathematics of mountain sculpture. By Verplank Colvin.

In Section H., Mr. W. J. McGee read a valuable paper on "Comparative Chronology," the principal points of which were to greatly lengthen the accepted period of geological history, particularly the later portion of it, but to shorten the period of human history. Mr. McGee objects decidedly to all supposed evidence of man in Tertiary time. It seems likely that the term "Tertiary" as applied to human remains in central Europe, has been misunderstood, and that the term is meant to designate, at least in some cases, simply the surface deposits which have more lately been denominated *drift*.

Mr. W. H. Holmes, who presided over Section H., objects to the terms "paleolithic" and "neolithic," as commonly employed to denote human implements of different dates and states of culture. He has found both in great abundance in the stone quarries of the ancients in Arkansas. The "paleolith" is the unworked "stock of the quarry," and as such was cached in quantities, or carried to great distances. The "neolith" was made at leisure, and as the occasion demanded, the same or similar "paleoliths" being wrought sometimes into one tool and sometimes into another.

According to Prof. E. D. Cope the "staked plains" of Texas are composed of Cenozoic strata, divisible into *Equus beds*, *Blanco Canon* and *Loup Fork*, the last being lowest, confirming the determinations of Prof. Hill. They are underlain by Triassic. The Equus beds have a well-known vertebrate fauna. The same is true of the Loup Fork. Between these faunas, which are totally separate and distinct, existed a paleontologic blank, which has now been filled by the discovery of the Blanco Canon beds. There are no marine forms either in these beds of the staked plains, or in the Triassic or Permian below. He considers the Equus beds as probably of the age of the LaFayette, but that is based wholly on paleontologic evidence.

Prof. Cope obtained remains of *Megalonyx* in the Blanco Canon beds, and several species of *Equus* in the Equus beds. He made a rich and varied collection of vertebrate remains.

A WORLD'S CONGRESS OF GEOLOGISTS will be held in Chicago, in the summer of 1893, in connection with the World's Columbian Exposition.

The excellent opportunity offered by this exposition for comparative studies of the mineral resources of the various countries of the globe, cannot fail to act as an inducement for geologists to assemble on this occasion. It is also announced that many States in the Union, as well as countries in other parts of the world, have made liberal appropriations for their geological exhibits at the Columbian Exposition; and the exposition as a whole will surely attract great numbers of scientific visitors.

The Congress will be held under the auspices of the World's Congress Auxiliary of the World's Columbian Exposition, which organization is recognized and supported by the United States' government as one of a series of congresses in the course of the exposition season, all intended to show the moral, social and intellectual advancement of the world at the present time.

The American Association for the Advancement of Science, on its 41st annual meeting, recently (Aug. 16th-22d) held in Rochester, N. Y., adopted resolutions cordially endorsing the congresses on the various branches of science within the scope of said association, and requested its various sections to appoint committees to coöperate with the respective local committees. Section E. (geology) acting upon this request, appointed a committee of the following geologists, viz.: Thomas C. Chamberlin (chairman), John C. Branner, Grove K. Gilbert, W J McGee, Rollin D. Salisbury, Eugene A. Smith, Charles D. Walcott, J. F. Whiteaves, Geo. H. Williams, H. L. Williams and N. H. Winchell. The local committee consists of Josua Lindahl (chairman), Edmund Andrews (v. chairman), Victor C. Alderson, W. R. Head, Oliver Marcy and Charles W. Rolfe.

The Directory will provide suitable places for meeting, and will extend to scientists in attendance all conveniences and courtesies consistent with the aims of the Auxiliary.

It is expected that arrangements will be made to secure the publication, *in extenso*, of the proceedings of the various congresses and the important papers to be presented at their sessions. These publications will be a memorial of the civilization of the Nineteenth Century.

We hope in the next number of the GEOLOGIST to communicate the exact date of the opening of the Geological Congress. All communications should, until further notice, be addressed to Dr. Josua Lindahl, Geologist, Springfield, Illinois.

DR. I. C. WHITE HAS SEVERED his connection with the West Virginia University, Prof. S. B. Brown, his late assistant, succeeding him in the chair of geology. Dr. White will hereafter devote his attention exclusively to his professional work in coal, oil and natural gas, and to his private business interests, which require much of his time.

OWING TO THE REFUSAL OF CONGRESS to vote the usual appropriation for the U. S. Geological Survey, all field work has been suspended, and all the assistants, and many of the principal geologists have been directed to close up their notes, putting them into condition for preservation or later use, as may be required. Many of the employés are discharged. The curtailment effects paleontology, petrography and chemistry most severely, and topography least. Messrs. Iddings, Penrose and Barus accompany Profs. Chamberlin and Salisbury to the University of Chicago.

ON THE NEWLY ESTABLISHED IOWA SURVEY, Mr. Charles R. Keyes is first assistant, and Prof. G. E. Patrick, of Ames, Iowa, is chemist.

TWO NEW DISCOVERIES OF MANGANESE ORE were reported by Mr. Edward Halse, at the recent meeting of the North of England Institute of Mining Engineers, one at Mulege, in Lower California, and the other at Arenig, Wales. The first is on the western shore of the Gulf of California. Here several outcrops of manganese ore veins are found crossing the trachyte which forms the bulk of the rock. The veins consist of psiomelane and gypsum and they vary in thickness from a few inches to three or four feet. The prevalent direction is about northwest to southeast. The chief veins run in wavy lines, consisting of a succession of curves, each a few feet long. The best ore is found at La Trinidad, where two veins intersect.

That found in Wales is in the Lower Silurian formation in Eastern Merionethshire. There are deposits of trappean ash and feldspathic porphyry, accompanied with manganese ore. This ore consists chiefly of psiomelane and occurs in much the same manner as does that of Lower California.

PROF. WILLIAM P. TROWBRIDGE, of Columbia College, died suddenly of heart failure, August 12, at his home in New Haven, Conn. In connection with the U. S. Coast Survey, he made many valuable contributions to scientific knowledge, and for a time held the position of scientific secretary to the superintendent of the Survey. His loss will be felt by the Institution in whose Faculty he held an honored position, and by the many scientific societies of which he was a valued member.

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[PALEONTOLOGICAL NOTES FROM THE LABORATORY OF BUCHTEL COLLEGE, NO. 2.]

THE HEAD OF DINICHTHYS.

By E. W. CLAYPOLE, Akron, O.

A specimen of the skull of *Dinichthys intermedius* recently found by Dr. W. Clark, of Berea, O., has supplied details previously unknown regarding the plates of which it was composed. I propose in this note to give some account of these in connection with a general description of the structure of the head of this species, all the main characters of which belong, doubtless, to the whole genus.

In his admirable "Monograph of Fossil Fishes" Dr. Newberry has given (pl. LII) a small outline sketch of what, in his opinion, was the general form of the head and of the individual plates of which it was built up. This may be regarded as a condensed summary of what had then been discovered of *Dinichthys*. The recently found specimen, as might have been expected from the skill and acumen of this well known author, coincides to a very large extent with his figure and illustrates his familiarity with the structure both of the fossil and recent forms.

The new specimen, however, corrects this diagram in a few points and adds others of some importance.

In the annexed figure* I have represented the right side of the

*The line of section through the orbital is placed (on the plate of the outside of the skull) about half an inch too far backward.

cranium and shown the various plates, and to as great a degree as possible, the way and extent of their overlap and underlap, but in consequence of their co-ossification these are in a few places not exactly and positively determinable. The specimen figured measures ten and a half inches from the tip of the nasal plate to the nuchal angle and the right side, which is scarcely displaced at all, is five and a half inches in breadth.

The principal new details in the skull are in the forms of some of the plates and the over and underlap which has not previously been represented.

Beside this, the structure of the upper jaw shows important additions, the principal of which will form the subject of a future "note."

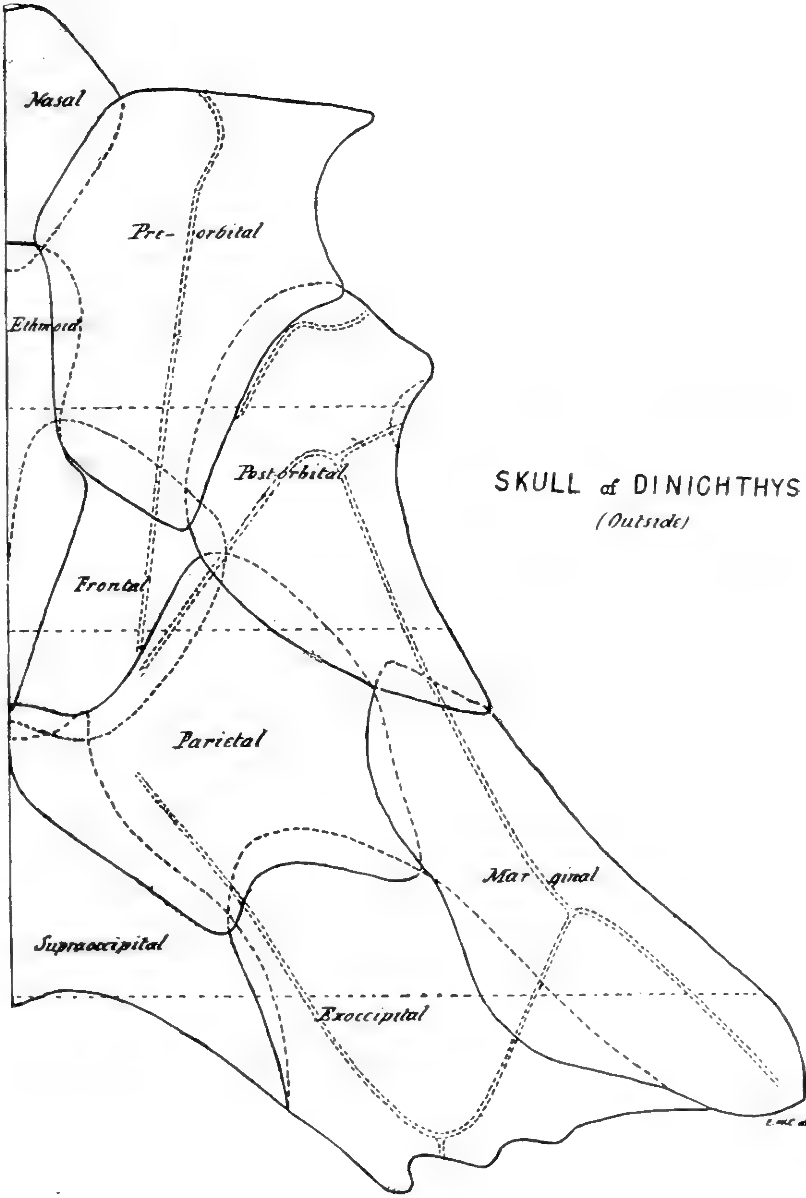
THE PLATES OF THE HEAD.

(1.) The *Supra-occipital* occupies the middle part of the hind margin, and is very massive, being one inch and a quarter thick at the maximum, extending forward as shown and very slightly underlapping both the adjoining lateral plates. Its inner face carries three ridges, one running forward and the other two outward and backward along the margin. These latter are very thick and heavy, and their sutures with the ex-occipitals are nearly vertical, not underrunning the latter to any considerable extent.

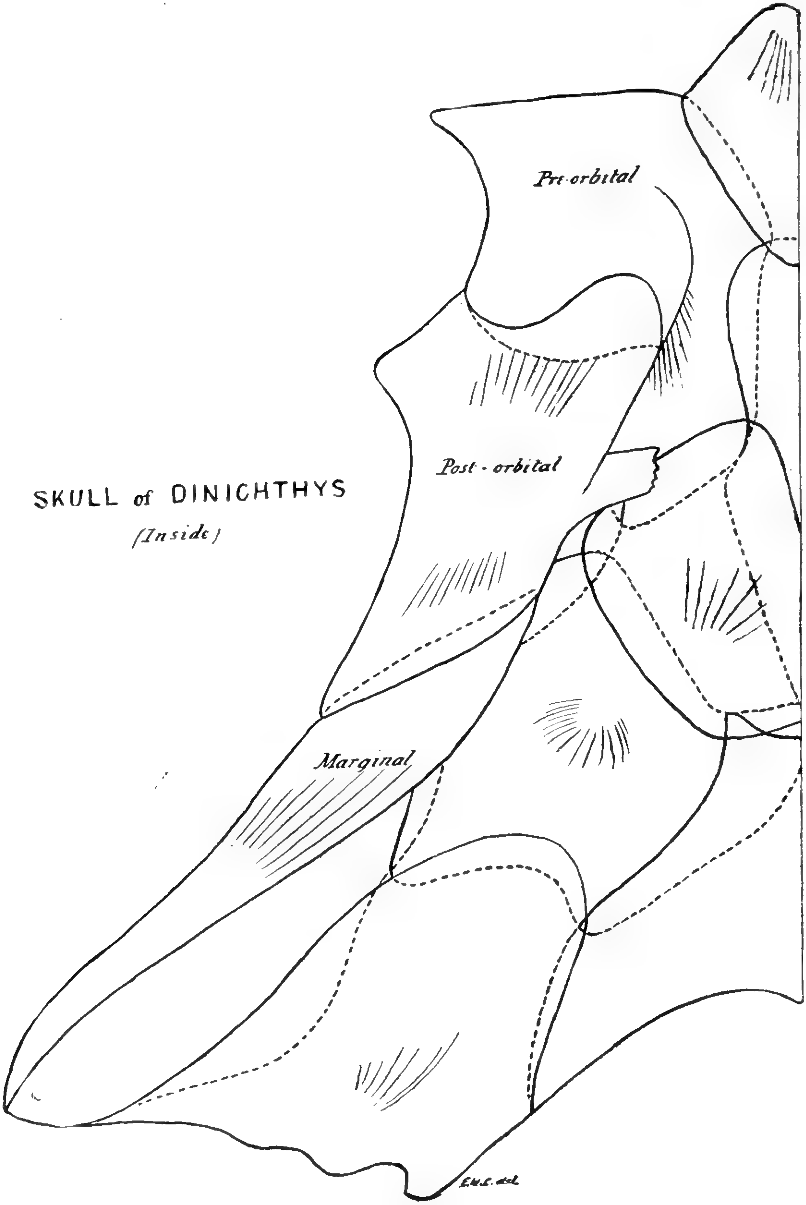
The sutures of the supra-occipital with both the parietal and ex-occipital or so nearly vertical that it is possible the overlap may be even the other way. This was certainly the case with *D. minor* whose supra-occipitals are often found separate. In these, the ex-occipital underlaps the supra-occipital, and the latter is considerably overlapped by the parietal. In direction they are nearly parallel with the axis of the head.

At the junction of these three ridges and in the middle of the nuchal line is the well known double socket on the inner face so plainly shown in Dr. Newberry's figures. (See pls. IV and LII of Monograph). The function of this socket is not exactly known, but it probably marks the place of insertion of some powerful muscle or ligament that connected the head with the rest of the body.

(2.) The *Ex-occipital* plate forms most of the hind margin of the head outside of the supra-occipital and carries the socket of that singular lock-joint with the supra-scapula which characterizes the Arthrodira. On the inner side it moderately overlaps



SKULL of DINICHTHYS
(Outside)



SKULL of DINICHTHYS
(Inside)

the supra-occipital and is in turn overlapped by the marginal (of Newb. and Traq.). In front it is overlapped by the concave edge of the parietal. It may be noted that this plate does not extend so far forward as was represented by Dr. Newberry. The space thus set free is taken up by the parietal.

(3.) The *Marginal* (N. and T.) forms the outer and hinder margin of the head running to a blunt point at its termination. As said above it overlaps the ex-occipital. It also overlaps the parietal inwardly and underlaps the post-orbital in front. It is a massive plate folding inward and downward as shown in the figure (see section) so as to form part of the roof of the mouth and at the same time to serve as the front wall ,of a deep fossa receiving the insertion of the muscle whose function was to lift the mandible (temporo-masseter). The hinder margin of this fossa is formed by the ridge of the supra-occipital mentioned above. These characters can be seen more or less plainly in the two figures above quoted (Monog. IV and LII) but can be more distinctly comprehended from the plan and sections given herewith.

(4.) The *Parietal* plate occupies a post-median position in the skull and is large and important. Meeting on the median line for a short distance its fellow of the opposite side, its edge inclines backward and outward overlapping largely the supra-occipital and ex-occipital behind. It is in turn overlapped by the marginal and post-orbital and again overlaps the frontal. It is thick and heavy, projecting far on the inner face of the skull and forming the front wall of the fossa already mentioned. It appears to have been the solidifying element of the mid-skull, extending as a ridge from the marginal to the supra-occipital on the inner face.

Judging from the conventional form which he has given to this plate in his restoration, its outlines cannot have been clearly defined in the specimen which Dr. Newberry studied. Instead of the small and elliptical area which he has assigned to it, it has a large size and an irregular outline and the insertion of this plate as above described makes a considerable difference in the post-median region of the skull.

(5.) The *Frontal* plate, as the parietal, meets its fellow along the mid-line for an inch or more and forms but a very small part of the outer face, being largely concealed by the adjoining plates all of which it underlaps. These are the parietal, supra-occipital, pre-orbital, post-orbital and ethmoid. It is a thin plate which covered in the brain. This organ lay in the space between the supra-occipital behind and the parietals post-laterally. How much of this it actually occupied it is not possible exactly to determine. The cavity measures five inches from side to side, but if analogy is a safe guide, as it probably is, some of this was occupied by the ear-capsules. It is probable that the brain proper was limited to the space within the forward projections of the parietal plates measuring about two and a half inches. This area is well outlined in Dr. Newberry's figures where its boundaries are much more clearly marked than in the specimen now described.

(6.) The *Frontal* plates, in consequence of their thinness, are usually, as in the present case, crushed down so that the brain-cavity is almost effaced. But the lateral spaces (ear-capsules) being protected by the massive post-orbitals are uninjured.

(7.) The *Post-orbital* plate continues the outline of the head from the marginal behind to the pre-orbital in front, and the post-orbital process forms the hind margin of the orbit. On the upper face this plate overlaps the parietal, the frontal and the marginal, and is slightly overlapped by the pre-orbital. It ends backward in a blunt point. As the marginal it folds under and forming a forward continuation of the above-mentioned ridge that bounds the temporo-masseter fossa protects the ear-capsule and the lateral aspect of the brain. This ridge gradually sinks until it is lost or is merged in another on the inner surface of the pre-orbital plate.

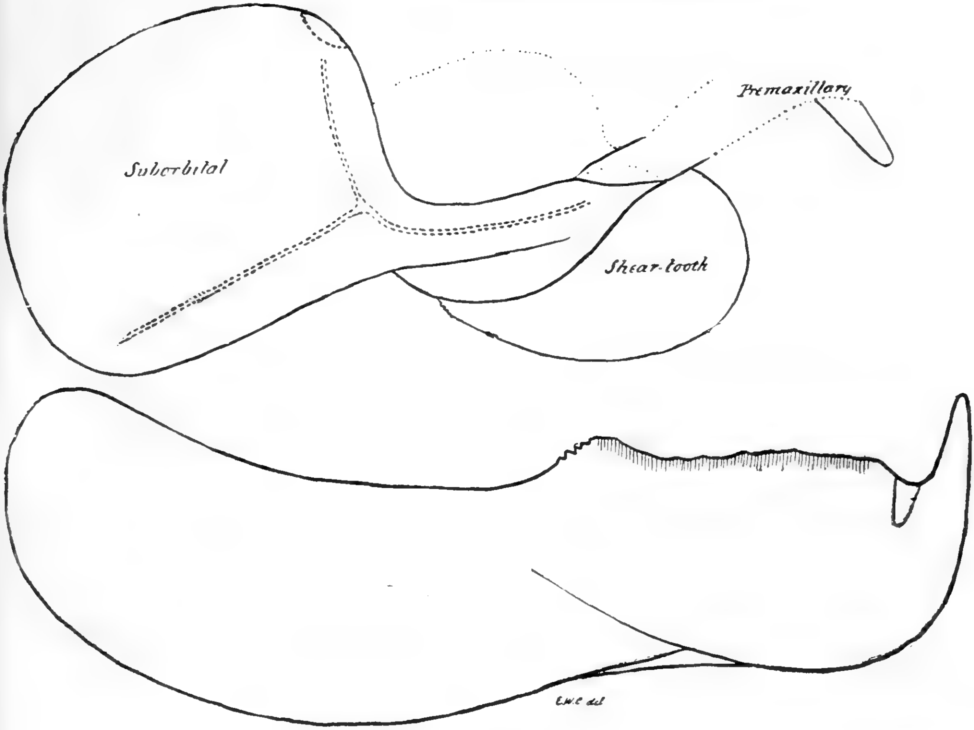
The natural strength of this plate due to its weight is largely increased by its form which may be seen by comparing the sections with the figure of the skull.

Just behind the post-orbital process, and on the lower face, is a small and shallow notch (indicated in the figure) for the reception of one of the angles of the sub-orbital plate.

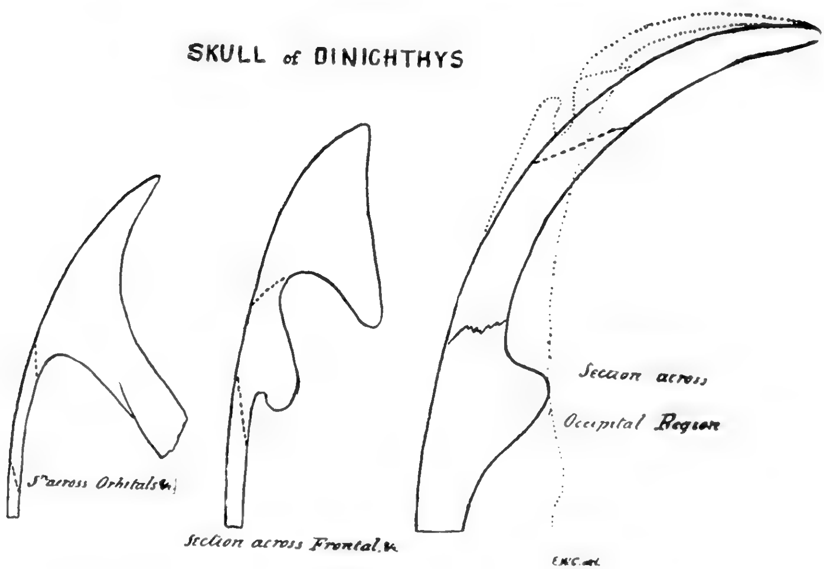
On its lower and inner margin is a strong, stout and cylindrical process an inch and a quarter long which evidently joined by a suture some one of the plates that formed the roof of the mouth. It slants downward and inward at a low angle (about 15° with the horizontal) so as to meet a plate that must in some way have corresponded in position and function to the vomer or the presphenoid of a recent fish. But no trace of any such plate remains in the specimen here described, though the two processes approached at their distal ends within half an inch of each other on the median line.

(8.) The *Pre-orbital* plate is large and outlines the orbit in

JAWS of DINICHTHYS



SKULL of DINICHTHYS



front. Its pre-orbital process is slenderer than the post-orbital and meets the front end of the sub-orbital at or near its junction with the premaxillary, thus completing the enclosure of the orbit. The pre-orbital overlaps the post-orbital, the ethmoid and the nasal. Its front edge runs from the nasal to the point of the pre-orbital process. It is strengthened on its inner face by a sharp, low ridge beginning at the point of the process and thickening inwardly as it rises for about one inch, after which it again sinks, until at length it merges in the low, flat end of the temporo-masseter and capsular ridge already described. This re-enforcement of the pre-orbital plate is connected with the insertion of the premaxillary tooth which was carried in part at least on its front edge, the remainder being borne by another plate to be mentioned later.

The nasal openings, or what were apparently such, were situated on the front edge of the nasal plate and extended in part on the inner front edge of the adjoining pre-orbital. In the specimen described they are on the very margin, but this is owing to the loss of the plate to be mentioned below. (No. 12.)

(9.) The *Ethmoid* plate is missing from this specimen, but it is so well known from other examples, and its size and relations are so clearly marked on the adjoining plates, that no difficulty is found in tracing it. It overlaps the hinder end of the nasal and a large area of the inner edge of the frontal, and underlaps the pre-orbital along its inner face. It resembles a spear-head in form with the point behind. On its inner face is seen the deep fontanelle, regarded as a place of lodgment for the extension of the pineal gland to a probable pineal eye. The fontanelle usually and perhaps normally, reaches the outer surface by a very small aperture, but was apparently in some specimens altogether closed.

(10.) The *Nasal* plate is trapezoidal in outline and completes the front of the head on the median line. It underlaps the pre-orbital and the ethmoid and overlaps to a very small extent, at its outer edge, the premaxillary plate, to be mentioned immediately. (No. 12.)

(11.) The *Sub-orbital* plate is a thin blade of bone four inches long, with thickened front and lower margins, passing at its lower front angle into a narrow but thicker projecting arm two and a half inches in length and extending forward. On the lower edge of this arm is a long, thin, crescentic plate which serves as a buttress or support externally for the great "shear-tooth" so characteristic of the genus. On its inner face this arm also carries an upwardly concave, horizontal plate which formed the floor of the orbit, enclosing, with the pre- and post-orbitals, the cavity for the eye. In front the sub-orbital formed a sutural connection with

(12.) The *Premaxillary.* This plate, which has been hitherto unknown, is not found in the specimen here described, but its presence has been established from others. A complete description of it will be given in a later note, as its relation to the teeth would require the introduction of the subject of the dentition. For the present it must suffice to say that it completed the outline of the fore-part of the head, enclosing the nasal openings and filling up the recess observable between the nasal and the pre-orbital plates.

The great shear-tooth set in the upper jaw on the lower face of the sub-orbital is shown in the diagram, but it has been so fully and clearly described and figured by Dr. Newberry that nothing further need be added here concerning it.

(13.) The *Post-marginal* plate, figured by Dr. Newberry in his diagram, is not found in the present specimen, nor are its relationships yet clearly known. It apparently formed one of several thin blades of bone whose office was the connection of the lower jaw with the head and which are usually found in so broken and confused a condition that their interpretation and re-construction have not hitherto been possible.

The principal "slime-canals" have been indicated. These are four in number. Three of them arise nearly together, about the meeting point of the supra-occipital, parietal and frontal plates. Of these, one which may be called the pre-orbital canal, runs almost straight to the anterior edge of the skull. It has not yet been traced on to the premaxillary plate. Another, which deserves the name of pre-orbital, runs to the central region of the plate of the same name where, slightly curving, it passes to the margin and is continued on to the sub-orbital plate to meet the sub-orbital canal. This runs from the hinder and lower angle of that plate forward to its junction with the premaxillary plate and will doubtless be found continuous there with another when that plate is better known. The occipital canal starts nearly with the first and second and runs outward and backward to the lock-joint of the supra-scapula, where it sends off a branch, the supra-scapular, which continues over that plate nearly in a straight line through its middle. Turning sharply, almost at a right angle, outward and forward, the occipital canal continues till it meets the marginal canal. This skirts the outer edge of the head from the hinder angle of the marginal plate to the post-orbital canal which it meets nearly in the centre of the plate of that name.

Besides these, there are indications of another, beginning in the angle between the pre-orbital and post-orbital canals and running forward and outward along the line of external suture of these plates. Turning sharply outward, after a short course, it terminates at the edge of the hinder part of the orbit. This is less distinct than the others in consequence of a possible confusion with the almost coincident pre-post-orbital suture.

EXTRA-MORAINIC DRIFT IN NEW JERSEY.

A. A. WRIGHT, Oberlin, O.

There is a snare in the words "terminal moraine" as applied to the great ice sheet of the Glacial Epoch. On the one hand there is not *one* terminal moraine, but many; a dozen perhaps, in retreating order, as urged by Mr. Upham for Minnesota, and as shown by the recent work of Mr. Leverett, in Ohio, and as illustrated everywhere within the glaciated area. On the other hand, the *terminal* terminal moraine, that is to say, the southernmost, is not terminal for the ice sheet, in the sense of accurately marking at every point the utmost extension of the land ice. Another expression, based upon a different geological conception, is needed for this line; and the words "glacial boundary" have been widely used and accepted. The terminal moraine cannot go south of the glacial boundary, but the glacial boundary may, and does often, lie many miles to the south of the terminal moraine. The area between the two lines, where they do not coincide, is marked with true signs of glaciation, and is covered with a thinner or thicker layer of transported material, which represents the work of the lobe of ice which once extended over it, but which was withdrawn before it had formed a definite boundary moraine. When we reflect that the Laurentide glacier was a fan-shaped sheet, radiating from a northern center, and not like the Swiss glaciers, gathered from a wide amphitheater to terminate below in an apex in a narrow valley, we can see that there is room for a wide variety in the terminal deposits.

The distinction between the terminal moraine and the true glacial boundary, was, as a matter of history, not so clearly in the minds of geologists when the task of tracing the terminal moraine acros, the continent was begun as it is now. Shortly after Mr. Upham had described the moraine as it exists on Long island, the official geologists of the New Jersey survey, professors Cook and Smock, traced the moraine across that state from Perth Amboy to Belvidere. Their annual reports for 1877 and '78 contain the details of the location and structure of this moraine. Professors Lewis and G. F. Wright then took up the work for the Pennsylvania survey; and their experience, especially in western Pennsylvania, convinced them of the importance of giving attention to the extra-morainic glacial deposits. Although it was assumed, both in the New Jersey and the Pennsylvania reports, that the terminal moraine rested essentially upon the glacial boundary, yet professor Lewis, in closing the report upon Pennsylvania, stated that a study of the extra morainic deposits would form the subject of a special report in the future. His untimely death, however, prevented him from completing the work.

The boundary line was carried through Ohio, Kentucky, Indiana and Illinois by professor G. F. Wright, and it will be noticed, both in his reports and in his maps, that he distinctly abandoned the purpose of tracing a continuous moraine, and pursued that of tracing the glacial boundary.

This frequent non-coincidence of the glacial boundary, and the terminal moraine, is the key by which are to be explained many of the observations to which I am about to allude.

During the present summer, I had the welcome opportunity of doing some field work in New Jersey, part of the time in company with professor G. F. Wright, whose wide experience in glacial geology will give to our joint observations a value which they could not possess if made by myself alone.

Attention has recently been drawn to the extra-morainic drift of New Jersey by professor Salisbury in two papers; the first being given at the Washington meeting of the Geological Society, one year ago; the second being published in the last annual report of the State survey.* In these papers many localities are given where glacial, or probably glacial, deposits have been found, south of the terminal moraine traced by professors Cook and Smock. Detailed descriptions of some of the deposits are given, and their origin is explained. I am indebted to these papers of professor Salisbury for a list of localities, many of which I have visited, and it is a pleasure to confirm the accuracy of the descriptions in most essential points. I shall only attempt to add some details, which it is hoped may throw additional light upon the nature of the deposits, and perhaps to show, that a somewhat different interpretation of their origin may be fairly entertained.

It would seem, as a result of our investigations, that the deposits at localities described as showing extra-morainic glaciation, extending from Belvidere and Oxford Furnace on the north, to the vicinity of Trenton and Monmouth Junction on the south, may all be comprehended under three groups.

1. *True Glacial Deposits*, laid down by the same ice sheet that deposited the moraine, and nearly contemporaneous with the moraine in their origin. The northern localities belong to this group.

2. *Water Deposits*, whether of current or delta formation, or carried by floating ice. The southernmost localities belong to this group.

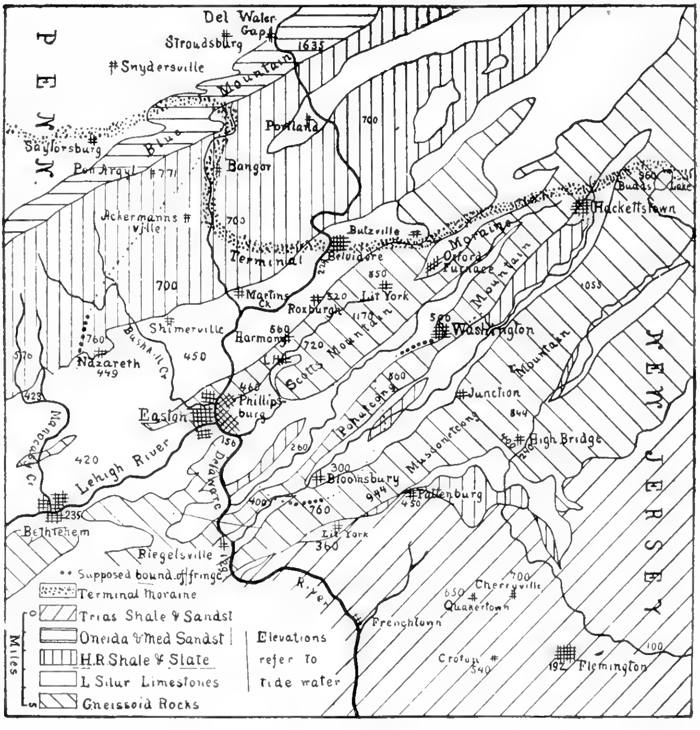
3. *Local Deposits*, which have the anomalous aspect of being glacial deposits in an unglaciated area. These, when better understood, are likely to be thrown back into the first group, or else be explained by agencies which are non-glacial. The two localities belonging to this group are High Bridge and Pattenburg.

The region containing the first group of deposits is in the southwestern Highlands of New Jersey. Three parallel mountain ridges run southwesterly through it; the Musconetcong, the Pohatcong and Scott's mountain. The ridges are of Archæan gneiss, and carry extensive deposits of iron ore. The intervening valleys are of magnesian limestone and Hudson River shale. The moraine runs eastwardly across these ridges, from Belvidere on the Delaware river through or near Butzville, Pequest Furnace, Townsbury, Hackettstown and Budds lake; rising from 300 feet above tide at Belvidere to 960 feet at Budds lake.

In this triangular area, between the moraine on the north, and

*Bull. Geol Soc. Am. Vol. 3, pp. 173-182.
Geol. Surv. N. J., Annual Report for 1891.

Musconetcong mountain on the south, it is possible to trace a well connected series of glacial deposits, embracing all those which I would refer to the first group. This covers the localities of Oxford Furnace, Oxford church, Little York, Brass Castle, Washington, Pleasant Valley, probably Mt. Bethel, though this place was not visited, Roxburgh, Harmony, Lower Harmony, the country northeast and east of Phillipsburg, and also southeast



to Springtown, Hughesville and Musconetcong mountain at a point two miles south of Bloomsbury.

Avoiding as far as possible the stream valleys, the higher divides were explored. These deposits were found at the following levels:

Oxford Furnace	520 ft.	Little York	850 ft.
Brass Castle	700 "	Washington	500 "
Harmony	560 "	Phillipsburg, N. E.	375 to 460 "

Musconetcong mountain, for a distance of three miles, at 700 to 760 feet.

On Scott's mountain, commencing three miles south of Roxburgh, for a distance of one mile, at 720 feet.

The water in the Delaware river has an elevation at Belvidere of 229 feet; at Phillipsburg and Easton 156 feet; at Riegelsville, at the lower end of Musconetcong mountain, 129 feet.

These figures are sufficient to show that the deposits in question cannot be attributed to the agency of streams, flowing from the glaciated regions lying northward, but on the contrary, must be due, as has been urged, to an ice-sheet upon the land.

The lithological and stratigraphical composition of the deposits, especially, proves them to be glacial. I scarcely know where to point for finer examples of genuine glacial deposits, than to those at Little York, Oxford Furnace, and the two cuts north of Washington, the latter of which are five miles south of the moraine. At Oxford Furnace, for example, where the exposure is from ten to twenty feet thick, there is the greatest variety of pebbles and bowlders, drawn from every source, and of various sizes and shapes, imbedded heterogeneously in a matrix of sand and clay. The predominating bowlders are of gneiss from the hills close at hand. All of *these* are angular in shape. Some of them show wavy, green epidotic stripes; some have rusty, ferruginous stripes; while others carry free quartz containing tourmaline crystals, like specimens quarried from the Oxford tunnel. Magnesian limestone also crops out, in place, here; and fragments of it, completely scored on every side, were imbedded in the till. There were also fragments of limonite ore; black flint, probably from the limestone; angular fragments of shale and slate, both striated and unstriated. But besides these elements, of local origin, one is able in a few moments, to take samples of many other rocks from far away, such as coarse granite, with large, pink orthoclase crystals; milky quartz, perhaps from the slate regions to the north; Medina sandstones or quartzites from the north, the dark gray, red and purplish varieties, as well as the more characteristic whitish variety, whose surface tans to such a beautiful, smooth leather color; Oneida conglomerate, a bowlder 2x2x6 feet, brought all the way from Kittatinny mountain, at least, its corners well rounded, as is the case with most of the northern material. Fragments of leached and spongy sandstone, perhaps feldspathic, are also found, while all are mixed in the fine confusion that demonstrates their deposition by an ice sheet.

The surface of the country all around is strewn with gneiss, and also with quartzite bowlders, which were traced continously from the moraine at Butzville southward to Washington. It is a matter of surprise that such pronounced glacial deposits should ever have been relegated to an unglaciated area. They are of the same nature as many of those which are made to do duty as portions of the terminal moraine. Although it was constantly in our minds, we were unable to see any chemical basis for separating these deposits from those of the moraine, such as superior oxidation or ferrugination. It should be noted that the gneiss which somewhat dominates the deposits at Oxford Furnace is often hornblendic and is seamed with iron ore.

Evidence of glaciation in several other parts of the triangle referred to was observed, though surface features had to be relied upon, as cuts and excavations were commonly wanting. For a distance of eight miles northeast of Phillipsburg, the high ground of Scott's mountain was explored upon two different roads. Everywhere there was found at least a thin scattering of foreign bowlders—conglomerates and quartzites predominating—while at several points there were notable accumulations of these, as at Harmony, a mile and a half east of Harmony, and two miles south of Lower Harmony. Southeast of Phillipsburg also they are generally distributed, with special accumulations on the pass between Springtown and Hughesville at an altitude of 320 feet, a mile east of Carpentersville at 250 feet, and for a distance of three miles on the north slope of Musconetcong mountain, south of Hughesville and Bloomsbury, at altitudes from 700 to 760 feet. Above this altitude, on the summits rising to 900 feet and more, only the local gneiss bowlders occur. This is the only locality where the ice-sheet is known to have reached Musconetcong mountain, though there are northern bowlders in the valley a mile or two west of New Hampton Junction at an elevation of 450 feet. These latter bowlders, however, were not traced into connection with the deposits northward at Washington, and it is possible that they have suffered some water transportation since the retreat of the ice.

So far as is yet known, the ice did not flow over any of the passes on Musconetcong mountain and down its southern slope. A little stream has carried some of the Kittatinny mountain quartzites down the south slope to Little York in Hunterdon county, from the 700 feet level just described. But it is most instructive to observe that, aside from this stream, the region about Little York is absolutely free, not only from northern bowlders, but from the gneissoid rocks of the overhanging mountain as well.

From the preceding account, therefore, it would appear that in western New Jersey the terminal moraine did not mark the true glacial boundary, but that the ice sheet must, for a certain period, have extended at least five miles further towards Washington, and at least 14 miles south of Belvidere upon the flanks of the musconetcong mountain.

The second group of reported glacial deposits south of the moraine are the southern ones, such as those at Monmouth Junction, N. J., and at Fallsington, Pa., three miles west of Trenton.*

As one approaches Monmouth Junction on the Pennsylvania railroad from Trenton, it is noticed that as soon as the city limits are left behind, the cuts are all in a red gravel, which I assume to be the Columbia formation. It is a flood deposit from the Delaware river, with a very uniform level of from 80 to 100 feet above tide. It continues the entire 15 miles to Monmouth Junction, and several miles beyond. At the Junction there is a cut 15 feet deep in a uniformly stratified gravel, characterized by white and yellow pebbles, mostly less than an inch in diameter. With infinite labor, one faintly, but really, striated, water-worn pebble was found, but there is no evidence that it was left in its

*At the meeting of the A. A. A. S., at which this paper was presented, professor Salisbury disclaimed the intention of asserting that an ice-sheet had existed as far south as Trenton, or over the center of Hunterdon county. The language, which I am sorry to have misinterpreted, is as follows: "The points in New Jersey and Pennsylvania mentioned above, however, [Oxford Furnace, High Bridge, Pattenburg, New Brunswick, Bethlehem, etc.], are not the southernmost localities where glaciated material is known to occur. Striated bowlders have been found both by Mr. Chas. E. Peet and the writer at and near Monmouth Junction, nearly twenty miles from the moraine at its nearest point, and fully forty miles south of the moraine on the same meridian. Glaciated material has also been found at Kingston, about half way between New Brunswick and Trenton. It has been found in Pennsylvania, about three miles west of Trenton, near Falsington. The similarity of the surface material of this locality to glacial drift (till) was first recognized by professor Smock. Striated material has also been found at Bridgeport (opposite Norristown), Pa., by Mr. Peet and the writer, at least ten miles south of the parallel of Trenton. As at Falsington, the striated material is here imbedded in clay of such character that were the locality known to have been covered with ice, its reference to till would be fully warranted." Bull. Geol. Soc. Am. Vol. 3, pp. 179-180.

Also: "In its southern extension the ice reached the region of the 'yellow gravel' formation." Ann. Report, State Geologist, p. 107.

present position by ice. A mile or two further on the cuts are shallower, and an admixture of coarser material is observed, though the red gravel continues. Angular fragments of eruptive diabase from immediately beneath, form a rough floor; well-rounded and polished northern quartzites, Oneida and Triassic conglomerates, and Triassic red sandstones up to a foot or more in diameter are imbedded in the gravel, while the surface for miles around is well supplied with these, and with larger, less rounded quartzites and conglomerates, up to two and three feet in diameter. Striated pebbles are very rare, and the whole can be accounted for, at this low level of 100 feet, by water and floating ice, without invoking the aid of an ice sheet.

In the third category I have placed the two deposits at High Bridge and Pattenburg, both at the foot of the southeastern slope of Musconetcong mountain; one, where the Jersey Central railroad comes across, and the other where the Lehigh Valley road comes out of its tunnel. In several particulars they are very different from the more northerly deposits, and they well merit the special descriptions and emphasis which professor Salisbury has bestowed upon them in his annual report. Whilst they are partly stratified and partly unstratified, containing material ranging from clay and sand up to bowlders of three and even seven feet in diameter, and are plentifully supplied with shale fragments with clean and sharp striations, still, on the other hand, it is to be noted:

1. That the material of the deposits is exclusively local. No northern rocks could be found. At High Bridge the deposit rests in a cradle of gneiss rock in place, and the hard bowlders are all gneissic or granitic, not rounded, and may have been gathered from the slope which rises 450 feet above. At Pattenburg the floor is Triassic shale and conglomerate, but the bowlders are gneissic, like those that are to-day creeping down the mountain slope on the north. The Hudson River shale and flinty limestones must be counted as local rock, even though no outcrop was detected in close proximity to the deposits.*

*The High Bridge deposit was visited before I had seen the true drift material to the north of it. The entire absence of any northern element cannot therefore be stated quite so confidently for High Bridge as for Pattenburg. While the discovery of a single well-identified northern pebble at either place would be of great significance, it could not alter the fact that these deposits are in radical contrast with the more northerly ones in the proportion of local material which they contain.

2. In the country round about these deposits, and especially on the high land to the northward, no signs of glaciation could be discovered. From High Bridge northward four miles to Whitehall, and thence southwesterly towards Glen Gardner, no signs of northern drift or ice-work were detected. Similar search north and south of Pattenburg gave the same results, as did also the study of adjoining railroad cuts, east and west on both roads; so that we are apparently presented with the spectacle of glacial deposits, in a region never invaded by an ice sheet; a matter which cannot fail to provoke further investigation. Were it not for the emphatic and convincing striation, both of the shale and gneissoid bowlders, we might turn with more hopefulness to an investigation of the possibilities concealed in landslides, and the secular creeping of plastic soil containing rock fragments, upon slopes of sufficient inclination in order to account, both for the striations of the rocks and the heterogeneous structure of the deposit. In the absence or meagerness of knowledge, however, upon this subject, and in view of the evidence that farther south upon this mountain, the ice-sheet abutted at a level of 760 feet, it may be more rational to suppose that over some passes, not yet discovered, some fingers of the ice-sheet may have extended for a sufficient time to form these limited and sharply isolated deposits.

Great relative antiquity as compared with the moraine to the north has been thought to attach to the deposit at High Bridge, as evinced by the extreme oxidation, leaching and ferrugination of its elements. The facts already stated will perhaps show why it possesses these characters. Its materials have never been subjected to the washing and scouring of a long glacial journey. The results of ancient oxidation and kaolinic decomposition are still visible in its elements just as they are in the rotting Archæan gneiss at its side, which still remains in place. It is also the case that the stratified portion of the deposit has been cemented into a veritable conglomerate, so tough that blasting was necessary in its excavation, by a highly ferruginous cement, whose origin is not far to seek. For here, as at Oxford Furnace, the gneiss contains a considerable proportion of ferruginous minerals, and at the High Bridge mines close by, it may be seen graduating into a large-grained hornblende schist, lying close to the layers of iron ore. The drainage water from such rocks as these will inevitably supply an abundant quantity of ferruginous material to the deposits at its base.

The interpretation given to these extra-morainic deposits must of necessity have its bearing upon the question as to the existence of an earlier ice-sheet which once covered the state of New Jersey as far south as Trenton and the line of the yellow gravels. So far as the deposits which we have discussed can be referred to the later ice-sheet, or to water transportation or to any other simpler and sufficient causes so far, of course, they must fail to give support to the theory of an earlier ice-sheet.

While not wishing to enter fully at the present time upon a discussion of the existence of such an ice-sheet in the past, I will, in closing, mention two points, which while negative, would still seem to have something more than a negative bearing against such a supposition.

The first is, that no such ice-sheet has done duty in depositing northern material over the large Triassic area of Hunterdon county. Not a northern pebble could I find upon the high plateau west of Flemington, in the region about Cherryville, Quakertown, Croton and Little York, where the elevation is from 500 to 650 feet. Nor are there any on the low ground at Flemington and southward and eastward, where the elevation is from 125 to 250 feet. At hundreds of places the entire thickness of the soil is exposed down to the rock in place, and the complete identity of the soil with the underlying rock, without any foreign admixture, is perfectly clear.

Finally there may be added one critical test, of the same sort, to which this supposed ice-sheet has failed to respond. It has failed to disturb the fragments of trap rock that lie upon the summit of Sourland mountain, where they have been exposed to the weather presumably since the close of the Jurassic age. Sourland mountain is a low swell, reaching an altitude of about 500 feet and extending from Neshanic, southwestwardly to the Delaware river at Lambertville. The center line is trap while this is flanked on both sides by indurated Triassic shales. I have crossed this mountain at three different places, at Buttonwood Corners, at a point two miles west of Rocktown and at Lambertville, and at no point do these diabase bowlders appear to have been carried over upon the borders of the Triassic, by any force whatever, not even by gravity. It is difficult to see how an ice-sheet could have passed over without transporting some of these fragments.

PLEISTOCENE PAPERS AT THE ROCHESTER MEETINGS.

During the sessions of the Geological Society of America, August 15 and 16, and of Section E (Geology and Geography) of the American Association for the Advancement of Science. August 17-22, 1892, in Rochester, N. Y., a considerable number of papers, which are here briefly noticed, related to the Pleistocene period.

GEOLOGICAL SOCIETY OF AMERICA.

Studies of the Connecticut Valley Glacier. By C. H. HITCHCOCK. The portion of the Connecticut river valley described in this paper extends from Lyme and Hanover south to Claremont, N. H. On each side of the valley the enclosing hills and uplands rise within a few miles to a hight of 500 feet or more above the river. Glacial striæ on these highlands bear somewhat uniformly about S. 30° E., while in the valley their prevailing direction is to the south or slighly west of south, conforming with the course of this depression. Bowlders and other drift materials have been transported in these diverse directions, southeastward on the higher country and southward in the valley. But occasionally striæ of an earlier southeastward glaciation are also found in the valley, preserved in hollows or on sheltered parts of the rock surface and surrounded by the marks of the southward ice-flow. Either the currents of the ice-sheet were here deflected southward during a late stage of the general glaciation, or a local glacier lingered in this valley after the ice on the higher land was melted, the latter being regarded by the author as the more probable explanation.

In the ensuing discussion, Mr. WARREN UPHAM spoke of the Connecticut valley esker (called a kame in the Geology of New Hampshire, vol. iii), which was traced twenty-four miles along the axis of this portion of the valley from Lyme, N. H., south to Windsor, Vt. When the receding border of the ice-sheet had become thinned by ablation, its surface here descended from each side toward the superglacial river by which the esker was being formed, and there was probably an indentation or embayment of the glacial boundary at the river's mouth. The glacial currents which had before passed southeastward even in the bottom of the valley appear to have then turned to the south and west of south, being deflected perpendicularly toward the indented edge of the waning ice-sheet.

Profs. E. W. CLAYPOLE and W. H. NILES doubted that an embayment of the ice-border could be formed in the Connecticut valley, and referred to the valley glaciers of alpine districts as suggestive that local glaciers might continue in valleys for some time after the departure of the ice-sheet from the adjoining highlands.

Mr. G. K. GILBERT spoke of the question whether the ablation of the departing ice-sheet caused its portion south of the White mountains and southeast of the Green mountain range to be at last divided by these highlands from the ice farther north, so that its pressure by a great thickness of ice in Canada ceased, leaving the southern portion to take new courses of outflow dependent only on its own mass and the contour of the land.

Conditions of accumulation of drumlins. By WARREN UPHAM. Descriptions of the various forms of these hills of glacial drift or till, and of their known distribution in the United States and Canada, were followed by discussion of the evidences that they were accumulated rapidly beneath the thinned and receding border of the ice-sheet, being probably in large part built up by lodgment of previously englacial drift. In becoming lodged on the drumlins or on other and low deposits of subglacial till, bowlders and pebbles of drift that had been englacial would be considerably striated and planed; but the drift which fell loosely on the surface from an englacial or superglacial position when the ice disappeared would be mostly angular, not being thus subjected to attrition. At a great distance from the edge of the ice-sheet and within all its central area, the currents of its upper and lower portions probably moved outward with nearly equal rates, the upper movement being somewhat faster than at the base. Upon a belt extending many miles back from the margin, however, where the slope of the ice-surface had more descent, the upper currents of the ice, unsupported on the outer side, would move several times faster than its lower currents, which were impeded by friction on the land. There would be accordingly within this belt a strong tendency of the ice to flow outward with curved currents, tending first to carry drift upward into the ice-sheet and later to bear it downward and deposit it partly beneath the edge of the ice and partly along the ice boundary. The author believed the drumlins to be submarginal drift accumulations chiefly so deposited inside the course of contemporaneous terminal moraines, or often formed during the glacial recession while no halt or re-advance of the receding ice-margin permitted the formation of moraines. But the irregular distribution and grouping of the drumlins, their absence upon many large areas thickly covered by drift, and the occasional occurrence of lone drumlins, remain to be explained and seem to present the most difficult problem relating to the action of the ice-sheet.

In discussion, Prof. R. D. SALISBURY thought the accumulation of drumlins easy to understand, but could not account for their occurrence in limited belts and groups or singly, while adjoining large tracts have none. The term englacial drift he would restrict to the drift carried long distances in the upper part of the ice without intermingling with the more plentiful drift in the basal part of the ice-sheet. Much of the drift transportation he believes to have taken place by dragging under the ice.

The extra-morainic drift of the Susquehanna valley. By G. FREDERICK WRIGHT. The extreme advance of the ice-sheet is held to be marked in the Susquehanna region by a thin mantle of drift with plentiful bowlders, extending to a distance of several miles in front of the conspicuous belt of hilly drift denominated the terminal moraine. In tracing the moraine through Pennsylvania, the author, with the late Prof. Henry Carvill Lewis, named this extra-morainic drift a "fringe," believing its deposition to have been nearly contemporaneous with the accumulation of the morainic hills. Terraces of stratified drift deposits, with infrequent bowlders, occurring farther south along the Susquehanna, which have been regarded by McGee as evidence of a marine submergence changing the valley to an estuary, are thought instead to be of fluvial origin, belonging to a time when the land there was slightly depressed, but not to the sea level, near the close of the Glacial period.

In discussion, Mr. W J MCGEE defended his interpretation of the terraces; and Prof. R. D. SALISBURY objected to the term "fringe," because this extra-morainic drift is referred by him, as also by McGee and others, to an earlier epoch of glaciation, apparently several times as long ago as the last glacial epoch when the moraine was formed.

SECTION E, AMERICAN ASSOCIATION.

Terminal moraines in New England. By C. H. HITCHCOCK.

After referring to the outer moraines which were traced fifteen years ago on Long Island, Martha's Vineyard, Nantucket, the Elizabeth Islands, and Cape Cod, and the moraine in northern Massachusetts recently reported by Mr. Ralph S. Tarr as reaching from Cape Ann westerly to the Connecticut river, the author described morainic belts which he has observed in New Hampshire and Vermont, characterized by drift hills and knolls of very irregular and broken contour, with abundant bowlders, and enclosing many ponds in depressions of the drift. One of these belts extends from the south side of Squam lake northeasterly to the vicinity of Conway, N. H. Another is traceable from near Burlington, Vt., eastward to Umbagog lake and the Rangely lakes in the west edge of Maine.

A passage in the history of the Cuyahoga river. By E. W. CLAYPOLE. This river of northern Ohio flows in a preglacial valley along nearly all its course from Akron to its mouth at Cleveland. In one place, however, the river flows in a rocky gorge on the west side of the old valley, which there had become filled with drift to a hight somewhat above its enclosing rock-wall. The postglacial erosion of this gorge and of the drift filling the valley seems capable of affording, with further study, a measure of the time since the recession of the ice-sheet from that area.

Notes bearing upon the changes of the preglacial drainage of western Illinois and eastern Iowa. By FRANK LEVERETT. Deep wells indicate that a drift-filled valley extends from the Mississippi river near its most eastern portion on the boundary of Iowa, above the Rock Island rapids, southeasterly to the Illinois river. It seems therefore worthy of inquiry whether this may have been the preglacial course of the Mississippi, since the rock gorges of the Rock Island and Des Moines rapids show that between southeastern Iowa and Illinois it has cut a new channel after being turned from an earlier valley by the ice-sheet. In preglacial and interglacial times, however, a large river ran in the present course of the Mississippi below Keokuk, and the drift-filled valley of this river was traced by Gen. G. K. Warren past the Des Moines rapids on their west side.

Extra-morainic drift in New Jersey. By A. A. WRIGHT. In the west part of northern New Jersey a general sheet of till covers the country southward from the terminal moraine at Belvidere for a distance of a dozen miles, across Scott's and Pohatcong mountains to the Musconetcong range. This drift sheet encloses plentiful bowlders and smaller rock fragments from formations lying north of the terminal moraine, and it is believed by the author and by Prof. G. F. Wright that it belongs to the same epoch of glaciation as the moraine itself. Close south of the Musconetcong mountain isolated deposits of till are found at Pattenburgh and High Bridge, which contain chiefly or only stones derived from adjacent formations, having none from the sandstone of the Kittatinny range, although that sandstone is plentiful in the drift between the terminal moraine and the Musconetcong mountain. The Pattenburgh and High Bridge deposits seem therefore referable to local glaciers, probably contemporaneous with the maximum extension of the general ice-sheet.

In discussion of this paper, Prof. R. D. SALISBURY and W J MCGEE attributed the extra-morainic drift of this district to a far more ancient glaciation than that which formed the terminal moraine at the farthest limit attained by the last ice-sheet. If the antiquity of the moraine be expressed by unity, that of the drift reaching thence southward, as shown by the progress of subaërial erosion and by the oxidation of the drift and the decay of its bowlders and pebbles, appears to require surely two figures for its expression. This drift beyond the moraine has been estimated variously to be from ten to fifty times as old as the moraine and the drift sheet that extends thence northward.

Paleobotany of the Yellow Gravel at Bridgeton, N. J. By ARTHUR HOLLICK. Leaves of about twenty-five species of plants, representing nearly twenty genera, among which are Magnolia, Asimina, Diospyros, and Persea, have been collected from the yellow gravel, sand, and loam at Bridgeton, in southern New Jersey, the only locality where fossils of any kind have been found in that formation. All these species are still living in the flora of the southern states, but none of them range north of New Jersey. It is the most completely recent collection of plants ever found in a fossilized condition.

Mr. MCGEE, in discussion, doubted that this deposit could be referred to either the Lafayette or Columbia formations, and suggested that more probably it had been eroded and re-deposited during the postglacial epoch, then receiving its fossil leaves.

Mr. LESTER F. WARD, having examined the locality, believed that the stratum containing the leaves is a part of the Lafayette formation, having not been disturbed since its original deposition. On this evidence the Lafayette epoch would belong in the Pleistocene period, instead of the Pliocene, to which it has been provisionally referred.

Submarine valleys on continental slopes. By WARREN UPHAM. The submarine fjord of the Hudson river, whose bottom is 2,844 feet below the sea level, and the similar valleys discovered by Prof. George Davidson off the coast of California, one of which sinks to the depth of 3,120 feet where it crosses the submarine contour line of 600 feet on the continental slope, are surpassed by the submerged cañon of the river Congo. This cañon, of which a description and map are given by Mr. J. Y. Buchanan, in the Scottish Geographical Magazine for May, 1887, extends about a hundred miles out to sea from the mouth of the Congo, and descends to a depth of more than 6,000 feet beneath the sea level. Along its last twenty miles before it enters the ocean, the Congo has a depth of 600 to 1,450 feet. At the mouth of the river the width of this gully, as Mr. Buchanan calls it, is three miles, and its depth is 2,000 feet. Thirty-five miles out to sea, the width of the gullied submarine valley or cañon is six miles, and its depth 3,440 feet. At the distance of seventy miles off shore the general slope has fallen off to the depth of 3,000 feet, and below this the cañon has an additional depth of 3,000 feet more, the sounding to its bottom being 6,000 feet. Several other very remarkable submarine valleys are found on this western coast of Africa near the equator.

Though Mr. Buchanan attributes these submerged cañons to the action of marine currents setting in landward under the lighter fresh water of the river, while the land, according to his belief, has held its present relation to the sea level, geologists who have studied the submarine valleys of the eastern and western coasts of North America will confidently refer their origin in Africa, as on our own continental borders, to a formerly greater altitude of the land when it stood higher than now by as great an amount as the depths of the cañons below the ocean's surface.

That the Congo submarine valley is not yet filled with the alluvial silt of the river, which discolors the surface water to the distance of many miles off shore, proves that the subsidence of the land from its former altitude was geologically recent. These great epeirogenic movements of the plateau forming the southern half of Africa, like the oscillations shown by submerged valleys and fjords of North America and Europe, ranging in depth to 4,080 feet in the Sogne fjord of Norway, took place doubtless no longer ago than during the Pleistocene or Glacial period, and the closing stage of the preceding Tertiary era. It seems also certain that these earth movements had an intimate relationship with the origin of the great lakes of Africa and with the accumulation and departure of the North American and European ice-sheets.

In discussion, Prof. JOSEPH LECONTE directed attention to the occurrence of submarine valleys on the California coast where no rivers now enter the sea. Not only a great uplift and subsequent depression of the continental plateau, but also vast outflows of lava and the formation of mountain ranges by which river courses have been changed, are there referable to late Tertiary and Quaternary time.

Pleistocene Geography. By W J MCGEE. A series of several maps was displayed and described, showing the extent of ice-sheets in North America during the first, second, and third glacial epochs which are recognized by the author, the extent of coastal submergence by the sea during these epochs, and the areas of the Pleistocene lakes Bonneville, Lahontan, and others, in the arid Great Basin of interior drainage. The deposition of the loess in the upper Missouri region was attributed to lakes and broad river floods, more or less obstructed by the ice-sheets. At present no sufficient data have been obtained for a correlation of the epochs of glaciation east of the Rocky mountains with those of the Cordilleran mountain belt and the Pacific coast.

Distribution of the Lafayette formation. By W J MCGEE. The gravel, sand, and loam beds formerly called the Appomattox formation, for which the name Lafayette is now substituted, occupy the coastal plain from New Jersey southward to northern Florida and westward through the gulf states into Mexico. An area of 100,000 square miles has this formation at its surface; upon an equal area the Lafayette beds are thinly covered by the similar but considerably later Columbia formation; and from still another area of the same extent the Lafayette formation has been removed by stream erosion. Its original extent was therefore not less than 300,000 square miles. It is believed to have been deposited while this low plain was covered by the sea, but the Appalachian mountain belt appears to have then stood somewhat above its present hight. Between the coastal submergences to which the Lafayette and Columbia beds are referred, this plain was elevated higher than now and the Chesapeake and Delaware bays were formed by the erosion of the Susquehanna and Delaware rivers. If time since the recession of the latest ice-sheet has been 7,000 years, as is shown to be probable by the studies of N. H. Winchell, Gilbert, Wright, and others, the amount of erosion since the Columbia and Lafayette epochs indicates that they were respectively some 200,000 years and 10,000,000 years ago, the Lafayette being apparently fifty times as long ago as the Columbia, and the latter thirty times older than the last glacial epoch.

In discussion, Mr. UPHAM questioned whether a simpler view of the epeirogenic movements producing the Lafayette formation might not be found in ascribing these beds to deposition by flooded rivers descending from the Appalachian mountain region and from the Mississippi basin, as shown by Hilgard, spreading the gravel, sand and loam over the coastal plain during the early part of a time of continental elevation. As this elevation increased, the rivers would attain steeper slopes and finally erode much of the deposits which they had previously made. During the culmination of the uplift, Chesapeake and Delaware bays were excavated, and erosion was in progress at a far more rapid rate than with the present low altitude of this region. The time ratios assigned to the Lafayette and Columbia formations in comparison with the last glacial epoch may therefore be greatly exaggerated, and they may belong wholly to the Pleistocene or Glacial period.

PROF. E. D. COPE doubted that the physical characters of the Lafayette beds could be produced by fluvial sedimentation.

Pres. T. C. CHAMBERLIN considered the question whether the Lafayette formation was mainly of marine or of fluvial origin undecided, but in New Jersey, at least, according to the studies of Prof. Salisbury, the latter view appears the more probable.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—EDINBURGH MEETING.

Opening address by PROF. C. LAPWORTH, LL. D., F. R. S., F. G. S., President of the Section of Geology.

It has, I believe, been the rule for the man who has been honored by election to the chair of President of the Geological Section of the British Association to address its members upon the recent advances made in that branch of geology in which he has himself been most immediately interested. It is not my intention upon the present occasion to depart from this time-honored custom; for it has both the merit of simplicity and the advantage of utility to recommend it. In this way each branch of our science, as it becomes in turn represented, not only submits to the workers in other departments a report of its own progress, but presents by implication a broad sketch of the entire geological landscape, seen through the colored glasses, it may be, of divisional prejudice, but at any rate instructive and corrective to the workers in other departments, as being taken from what is to them a novel and an unfamiliar point of view.

Now every tyro in geology is well aware of the fact that the very backbone of geological science is constituted by what is known as stratigraphical geology, or the study of the geological formations. These formations, stratified and unstratified, build up all that part of the visible earth-crust which is accessible to the investigator. Their outcropping edges constitute the visible exterior of our globe, the surface of which forms the physical geography of the present day, and their internal characters and inter-relationships afford us our only clues to the physical geographies of bygone ages. Within them lies enshrined all that we may ever hope to discover of the history and the development of the habitable world of the past.

These formations are to the stratigraphical geologist what species are to the biologist, or what the heavenly bodies are to the astronomer. It was the discovery of these formations which first elevated geology to the rank of a science. In the working out of their characters, their relationships, their development, and their origin, geology finds its means, its aims, and its justification. Whatever fresh material our science may yield to man's full conception of nature, organic and inorganic, must of necessity be grouped around these special and peculiar objects of its contemplation.

When the great Werner first taught that our earth-crust was made up of superimposed rock-sheets or formations arranged in determinable order, the value of his conclusions from an economic point of view soon led to their enthusiastic and careful study; and his crude theory of their successive precipitation from a universal chaotic ocean disarmed the suspicions of the many until the facts themselves had gained such a wide acceptance that denial was no longer possible. But when the greater Hutton asserted that each of these rock formations was in reality nothing more nor less than the recemented ruins of an earlier world, the prejudices of mankind at large were loosed at a single stroke. Like Galileo's assertion of the movement of the globe, this demanded such a simple and apparently undignified mode of creation that there is no wonder that, even down to the present day, there still exist some to whom this is a hard saying, to be taken, if taken at all, in homœopathic doses and with undisguised reluctance.

Hutton, as regards his philosophy, was, as we know, far in advance of his time. With all the boldness of conviction he unflinchingly followed out these ideas to their legitimate results. He claimed that as the stratified formations were composed of similar materials—sands, clays, limestones, and muds—to those now being laid down in the seas around our present coasts they must, like them, have been the products of ordinary natural agencies—of rain, rivers and sea waters, internal heat and external cold—acting precisely as they act now. And further as these formations lie one below the other, in apparently endless downward succession, and are all formed more or less of these fragmentary materials, so the present order of natural phenomena must have existed for untold ages. Indeed, to the commencement of this order he frankly admits, "I see no trace of a beginning or sign of an end."

The history of the slow acceptance of Hutton's doctrines, even among geologists, is, of course, perfectly familiar to us all. William Smith reduced the disputed formations to order, and showed that not only was each composed of the ruins of a vanished land, but that each contained in its fossils the proof that it was deposited in a vanished sea inhabited by special life creation. Cuvier followed, and placed it beyond question that the fossilized relics of these departed beings were such as made it absolutely unquestionable that these creatures might well have inhabited the earth at the present day. Lyell completed the cycle by demonstrating stage by stage the efficiency of present natural agencies to do all the work required for the degradation and rebuilding of the formations. Since his day the students of stratigraphical geology have universally acknowledged that in the study of present geographical causes lies the key to the geological formations and the inorganic world of the past.

In this way the road was paved for Darwin and the doctrine of descent. The aid which had been so ungrudgingly afforded by biology to geology was repaid by one of the noblest presents ever made by one science to another. For the purposes of geology, the science of biology had practically completed a double demonstration: first, that the extinct life discernible in the geological formations was linked inseparably with the organic life of the present; and, second, that every fossil recognized by the geologist was the relic of a creature that might well have existed upon the surface of the earth at the present time. Geology repaid its obligation to biology by the still greater two-fold demonstration: first, that in the economy of nature the most insignificant causes are competent to the grandest effects, if only a sufficiency of time be granted them; and, second, that in the geological formations we have the evidences of the actual existence of those mighty eons in which such work might be done.

The doctrine of organic evolution would always have remained a metaphysical dream had geology not given the time in which the evolution could be accomplished. The ability of present causes to bring about slow and cumulative changes in the species is, to all intents and purposes, a biological application of Hutton's ideas with respect to the origin of the geological formations. Darwin was a biological evolutionist, because he was first a uniformitarian geologist. Biology is preeminent to-day among the natural sciences, because its younger sister, Geology, gave it the means.

But the inevitable consequence of the work of Darwin and his colleagues was that the centre of gravity, so to speak, of popular regard and public controversy was suddenly shifted from stratigraphical geology to biology. Since that day stratigraphical geology, to its great comfort and advantage, has gone quietly on its way unchallenged, and all its more recent results have, at least by the majority of the wonder-loving public, been practically ignored.

Indeed, to the outside observer it would seem as if stratigraphical geology for the last thirty years had been practically at a standstill. The startling discoveries and speculations of the brilliant stratigraphists of the end of the last century and first half of the present forced the geology of their day into the very front rank of the natural sciences, and made it perhaps the most conspicuous of them all in the eyes of the world at large. Since that time, however, their successors have been mainly occupied in completing the work of the great pioneers. The stratigraphical geologists themselves have been almost wholly occupied in laying down upon our maps the superficial outlines of the great formations, and working out their inter-relationships and subdivisions. At the present day the young stratigraphical student soon learns that all the limits of our great formations have been laid down with accuracy and clearness, and finds but little to add to the accepted nomenclature of the time.

Our palæontologists also have equally busied themselves in working out the rich store of the organic remains of the geological formations, and the youthful investigator soon discovers that almost every fossil he is able to detect in the field has already been named, figured, and described, and its place in the geological record more or less accurately fixed.

In France, in Germany, in Norway, Sweden, and elsewhere, in Canada and in the United States, work as thorough and as satisfactory has been accomplished, and the local development of the great stratified formations and their fossils laid down with detail and clearness.

Many an unfledged, but aspiring geologist, alive to these facts, and contrasting the well-mapped ground of the present time with the virgin lands of the days of the great pioneers, finds it hard to stifle a feeling of keen regret that there are nowadays no new geological worlds to conquer, no new systems to discover and name, and no strange and unexpected faunas to unearth and bring forth to the astonished light of day. The youth of stratigraphical geology, with all its wonder and freshness, seems to have departed, and all that remains is to accept, to commemorate, and to round off the glorious victories of the dead heroes of our science.

But to the patient stratigraphical veteran, who has kept his eyes open to discoveries new and old, this lull in the war of geological controversy presents itself rather as a grateful breathing time; the more grateful as he sees looming rapidly up in front the vague outlines of those oncoming problems which it will be the duty and the joy of the rising race of young geologists to grapple with and to conquer, as their fathers met and vanquished the problems of the past. He knows perfectly well that Geology is yet in her merest youth, and that to justify even her very existence there can be no rest until the whole earth-crust and all its phenomena, past, present, and to come, have been subjected to the domain of human thought and comprehension. There can be no more finality in Geology than in any other science; the discovery of to-day is merely the stepping-stone to the discovery of to-morrow; the living theory of to-morrow is nourished by the relics of its parent theory of to-day.

Now if we ask what are these formations which constitute the objects of study of the stratigraphical geologist, I am afraid that, as in the case of the species of the biologist, no two authorities would agree in framing precisely the same definition. The original use of the term *formation* was of necessity lithological, and even now the name is most naturally applied to any great sheet of rock which forms a component member of the earth-crust; whether the term be used specifically for a thin homogeneous sheet of rock like the Stonesfield slate, ranging over a few square miles; or generically, for a compound sheet of rock, like the Old Red Sandstone, many thousands of feet in thickness, but whose collective lithological characteristics give it an individuality recognizable over the breadth of an entire continent.

When Werner originally discovered that the "formations" of Saxony followed each other in a certain recognizable order, a second characteristic of a formation became superposed upon the original lithological conception—namely, that of determinate "relative position." And when William Smith proved that each of the formations of the English Midlands was distinguished by an assemblage of organic remains peculiar to itself, there became added yet a third criterion—that of the possession of "characteristic fossils."

But these later superposed conceptions of time-succession and life-type are far better expressed by dividing the geological formations into zoological *zones*, on the one hand, and grouping them together, on the other hand, into chronological *systems*. For in the experience of every geologist he finds his mind instinctively harking back to the bare lithological application of the word "formation," and I do not see that any real advantage is gained by departing from the primitive use of the term.

A *zone*, which may be regarded as the *unit* of *palæontological succession*, is marked by the presence of a special fossil, and may include one or many subordinate formations. A *system*, which is, broadly speaking, the *unit of geological succession*, includes many "zones," and often, but not always, many "formations." A *formation*, which is the *unit of geological stratigraphy*, is a rock sheet composed of many strata possessing common lithological characters. The formation may be simple, like the Chalk, or compound, like the New Red sandstone; but, simple or compound, local or regional, it must be always recognizable, geographically and geologically, as a lithological individual.

As regards the natural grouping of these lithological individuals as such, fair progress has been made of late years, and our information is growing apace. We know that there are at any rate three main groups: 1st, the stratified formations due to the action of moving water above the earth-crust; 2d, the igneous formations which are derived from below the earth-crust; 3d, the metamorphic formations which have undergone change within the earth-crust itself. We know also that of these three the only group which has hitherto proved itself available for the purpose of reading the past history of the globe is that of the stratified formations.

Studying these stratified formations therefore in greater detail, we find that they fall naturally in their turn into two sets—viz., a mechanical set of pebble beds, sandstones and clays formed of rock fragments washed off the land into the waters, and an organic set of limestones, chalk, &c., formed of the shells and exuviæ of marine organisms.

But when we attempt a further division of these two sets, our classification soon begins to lose its definiteness. We infer that some formations, such as the Old Red and the Triassic, were the comparatively rapid deposits of lakes and inland seas; that others, like the Coal Measures, London clay, &c., were the less rapid deposits of lagoons, river valleys, deltas, and the like; that others, like our finely laminated shales and clays of the Silurian and Jurassic, were the slower deposits of the broader seas; and finally, that others, like our Chalk and Greensand, were possibly the extremely slow deposits of the more oceanic deeps.

Nevertheless, after looking at the formations collectively, there remains no doubt whatever in the mind of the geologist that their mechanical members are the results of the aqueous degradation of vanished lands, and that their organic members are the accumulated relics of the stony secretions of what once were living beings. Neither is there any possibility of escape from the conclusion that they have all been deposited by water in the superficial hollows of the sea-bottoms and ocean floors of the earth-crust of their time.

In the life of every individual stratified formation of the mechanical type we can always distinguish three stages: first, the stage of erosion and transportation, in which the rock fragments were worn off the rocks of the higher ground and washed down by rain and rivers to the sea; second, a stage of deposition and consolidation below the surface of the quiet waters; and third, a final stage in which the completed rock formation was bent and upheaved, in part at least, into solid land. In the formations of the organic type three corresponding stages are equally discernible: first, the period of mineral secretion by organized beings; second, the period of deposition and consolidation; and third, the final period of local elevation in mass. But one and all, mechanical and organic alike, they bear in their composition, in their arrangement, and in their fossils, abundant and irresistible evidences that they *were* the products, and that now they *are* the memorials of the physical geography of their time.

Guided by the principles of Hutton and Lyell, geologists have worked out with great care and completeness the effects of those agencies which rule in the first of these three life-stages in the history of a mechanical formation. No present geological processes are better known to the young geologist than those of denudation, erosion, and transportation, so familiar to us in the eloquent works of our president. They form together the subject matter of that most wonderfully fascinating chapter in geology, which, from its modest opening among the quiet Norfolk sandhills,sweeps upwards and onwards without a break to its magnificent close on the brink of the gorge of the Colorado. But our knowledge of the detailed processes of deposition and consolidation which rule in the second stage is still exceedingly imperfect, although a flood of light has been thrown upon the subject by the brilliant results of the *Challenger* expedition. And we are compelled to admit that our knowledge of the operations of those agencies which rule in the processes of upheaval and depression is as yet almost nil; and what little we have already learnt of the effects of those agencies is the prey of hosts of conflicting theories that merely serve to annoy and bewilder the working student of the science.

But not one of the formative triad of detrition, deposition, and elevation can exist without the others. No detrition is possible without the previous upheaval of the rock-sheet from which material can be removed; no deposition is possible without the previous depression of the rock-sheet which forms the basin in which the fragmentary material can be laid down.

Our knowledge, therefore, of the origin and meaning of any geological formation whatever, can at most be only fragmentary until this third chapter in the life-history of the geological formation has been attacked in earnest.

Now all the rich store of knowledge that we possess respecting the first stage in the life of a geological formation has been derived from a comparison of certain phenomena which the stratigraphical geologist finds in the rock formations of the past, with correspondent phenomena which the physical geographer discovers on the surface of the earth of the present. And all that we know of the second stage again has been obtained in precisely the same way. Surely analogy and common sense both teach us that all which is likely to be of permanent value to us as regards the final stage of elevation and depression must first be sought for in the same direction.

Within the last twenty years or so many interesting and vital discoveries have been made in the stratigraphy of the rock formations, which bear largely upon this obscure chapter of elevation and depression. And I propose on this occasion that we try to summarize a few of these new facts, and then, reading them in conjunction with what we actually know of the physical geography of the present day, try to ascertain how such mutual agreement as we can discover may serve to aid the stratigraphical geologist in his interpretation of the true meaning of the geological formations themselves. We may not hope for many years to come to read the whole of this geological chapter, but we may perhaps modestly essay an interpretation of one or two of the opening paragraphs.

In the physical geography of the present day we find the exterior of our terraqueous globe divided between the two elements land and water. We know that the solid geological formations exist everywhere beneath the visible surface of the lands, but of their existence under the present ocean floor we have as yet no absolute certainty. We know both the form of the surface and the composition of the outer layers of the continental parts of the lithosphere; we only know as yet even in outline the form of the surface of its oceanic portions. The surface of each of our great continental masses of land resembles that of a long and broad arch-like form, of which we see the simplest type in the New World. The surface of the North American arch is sagged downwards in the middle into a central depression which lies between two long marginal plateaux, and these plateaux are finally crowned by the wrinkled crests which form its modern mountain systems. The surface of each of our ocean floors exactly resembles that of a continent turned upside down. Taking the Atlantic as our simplest type, we may say that the surface of an ocean basin resembles that of a mighty trough or syncline,buckled up more or less centrally into a medial ridge, which is bounded by two long and deep marginal hollows, in the cores of which still deeper grooves sink to the profoundest depths. This complementary relationship descends even to the minor features of the two. Where the great continental sag sinks below the ocean level, we have our gulfs and our Mediterraneans, seen in our type continent as the Mexican gulf and Hudson bay. Where the central oceanic buckle attains the water line, we have our oceanic islands, seen in our type ocean as St. Helena and the Azores. Although these apparent crust-waves are neither equal in size nor symmetrical in form, this complementary relationship between them is always discernible. The broad Pacific depression seems to answer to the broad elevation of the Old World—the narrow trough of the Atlantic to the narrow continent of America.

Every primary wave of the earth's surface is broken up into minor waves,in each of which the ridge and its complementary trough are always recognizable. The compound ridge of the Alps answers to the compound Mediterranean trough; the continuous western mountain chains of the Americas to the continuous hollow of the eastern Pacific which bounds them; the sweep of the crest of the Himalaya to the curve of the Indo-Gangetic depression. Even where the surface waves of the lithosphere lie more or less buried beneath the waters of the ocean and the seas, the same rule always obtains. The island chains of the Antilles answer to the several Caribbean abysses, those of the Ægean archipelago answer to the Levantine deeps.

Draw a section of the surface of the lithosphere along a great circle in any direction, the rule remains always the same; crest and trough, hight and hollow, succeed each other in endless sequence, of every gradation of size, of every degree of complexity. Sometimes the ridges are continental, like those of the Americas; sometimes orographic, like those of the Himalaya; sometimes they are local, like those of the English Weald. But so long as we do not descend to minor details we find that every line drawn across the earth's surface at the present day rises and falls like the imaginary line drawn across the surface of the waves of the ocean. No rise of that line occurs without its complementary depression; the two always go together, and must, of necessity, be considered together. Each pair constitutes one of those *geographical units of form* of which every continuous direct line carried over the surface of the lithosphere of our globe is made up. This unit is always made up of an arch-like rise and a trough-like depression, which shade into each other along a middle line of contrary curvature. It resembles the letter S or Hogarth's line of beauty, and is clearly similar in form to the typical wave of the physicist. Here, then, we reach a very simple and natural conclusion, viz.: the surface of the earth-crust of the present day resembles that of a series of crust-waves of different lengths and different amplitudes, more or less irregular and complex, it is true, but everywhere alternately rising and falling in symmetrical halves like the waves of the sea.

Now this rolling wave-like earth-surface is formed of the outcropping edges of the rock formations which are the special objects of study of the stratigraphical geologist. If, therefore, the physiognomy of the face of our globe is any real index of the character of the personality of the earth-crust beneath it, these collective geographical features should be precisely those which answer to the collective structural characters of the geological formations.

In the earlier days of geology one of the first points recognized by our stratigraphists was the fact that the formations were successive lithological sheets, whose truncated outcropping edges formed the present surface of the land, and that these sheets lay inclined at an angle one over the other, or as William Smith quaintly expressed it, like a tilted "pile of slices of bread and butter." But as discovery progressed the explanation of this arrangement soon became evident. The formations revealed themselves as a series of what had originally been deposited as horizontal sheets, lying in regular order one over the other, but which had been subsequently bent up into alternating arches and troughs (*i. e.* the anticlines and synclines of the geologist). Their visible parts, which now constitute the surface of our habitable lands, were simply those parts of the formations which are cut by the irregular plane of the present earth's surface. All those parts of the great arches and troughs formerly occurring above that plane have been removed by denudation; all those parts below that plane lie buried still, out of sight within the solid earth-crust.

Although in every geological section of sufficient extent it was seen that the anticline or arch never occurred without the syncline or trough —in other words, that there was never a rise without a corresponding fall of the stratum—yet it is only of late years that the stratigraphical geologist has come clearly to recognize the fact that the anticline and syncline must be considered together, and must be united as a single crust-wave. For the arch is never present without its complementary trough, and the two together constitute the *tectonic*, *structural*, or *orographic unit*, namely, *The Fold*, the study of which, so brilliantly inaugurated by Heim in his "Mechanismus der Gebirgsbildung," is destined, I believe, in time, to give us the clue to the laws which rule in the local elevation and depression of the earth-crust, and furnish us with the means of discovery of the occult causes which lie at the source of those superficial irregularities which give to the face of our globe its variety, its beauty, and its habitability.

We have said already that this wave or fold of the geologist resembles that of the wave of the physicist. Now we may regard such a wave as formed of two parts, the arch-like part above and the trough-like part below. The length of the wave is naturally the length of the axial line joining the outer extremities of the arch and trough, and passing through the centre, node, or point of origin of the wave itself, which bisects the line of contrary curvature. The amplitude of the wave is the hight of the arch added to the depth of the trough. The arch part of such a wave, if perfectly symmetrical, may clearly be regarded as belonging either to a wave traveling to the right, in which case the complementary trough is the one in that direction, or it may be regarded as belonging to a wave traveling to the left, in which case its trough must be the one in that direction. But as in the case of the shore wave, the advancing slope of the wave is always the steeper, and the real centre of the wave must lie half-way down this steeper slope; so there is no difficulty in recognizing the centre of a geological fold and fixing the real direction of movement.

The fold of the geologist differs from the ordinary wave of the physicist essentially in the fact that even in its most elementary conception, as that of a plate bent by a pressure applied from opposite sides, it necessarily includes the element of thickness. And this being the case, the rock sheet which is being folded and curved has different layers of its thickness affected differently. In the arch of the fold the upper layers of the rock sheet are extended, while its lower layers are compressed. On the contrary in the trough of the fold the upper layers are compressed and the lower layers are extended. But in arch and trough alike there exists a central layer, which, beyond taking up the common wave-like form, remains practically unaffected.

But the geological fold has in addition to length and thickness, the further element of breadth, and this fact greatly complicates the phenomena.

Many of the movements which take place in a rock sheet which is being folded, or in other words those produced by the bending of a compound sheet composed of many leaves, can be fairly well studied in a very simple experiment. Take an ordinary large note-book, say an inch in thickness, with flexible covers. Rule carefully a series of parallel lines across the edges of the leaves at the top of the book, about ⅛ of an inch apart, and exactly at right angles to the plane of the cover. Then, holding the front edges loosely, press the book slowly from back and front into an S-like form until it can be pressed no further. As the wave grows, it will be noticed that the cross lines which have been drawn on the upper edge of the book remain fairly parallel throughout the whole of the folding process, except in the central third of the book, where they arrange themselves into a beautiful sheath-like form, showing how much the leaves of the book have sheared or slidden over each other in this central portion. It will also be seen when the S is complete that the book has been forced into a third of its former breadth. It is clear that the wave which the book now forms must be regarded as made up of three sections, viz.: a section forming the outside of the trough on the one side, and a section forming the outside of the arch on the other, and a central or common section, which may be regarded either as uniting or dividing the other two.

As this experiment gives us a fair representation of what takes place in a geological fold, we see at a glance that the geologist is forced to divide his fold into three parts—an arch limb, a trough limb, and a middle limb—which last we may call the *copula* or the *septum*, according as we regard it as connecting or dividing the other two. Our note-book experiment shows us also that in the trough limb and the arch limb the leaves or layers undergo scarcely any change of position beyond taking on the growing curvature of the wave. But the layers in the central part, or *septum*, undergo sliding and shearing. It will be found also, by gripping the unbound parts of the book firmly and practicing the folding in different ways, that this *septum* is also a region of warping and twisting. This simple experiment should be practiced again and again until all these points are apparent, and the various stages of the folding process become clear; the surface of the book being forced first into a gentle arch-like rise with a corresponding trough-like fall; then stage by stage the arch should be pushed over onto the trough until the surfaces of the two are in contact and the book can be folded no further.

In the structure of our modern mountain ranges we discover the most beautiful illustrations of the bending and folding of the rocky formations of the earth-crust. The early results of Rogers among the Alleghanies, of Lory and Favre in the western Alps, have been greatly extended of late years by the discoveries of Heim and Baltzer in the central Alps, of Bertrand in Provence, of Margerie in Languedoc, of Dutton and his colleagues in the western ranges of America, and of Peach and Horne and others in the older rocks of Britain. The light these researches throw upon the phenomena of mountain structure will be found admirably summarized and discussed in the works of Leconte, of Dana, of Daubree, of Reade, of Heim, and finally in the magnificent work of Suess, the "Antlitz der Erde," of which only the first two volumes have yet appeared.

Looking first at the mountain fold in its simplest form as that of a bent rock-plate, composed of many layers which have been forced into two similar arc-like forms, the convexities of which are turned, the one upwards and the other downwards, we find in the present mountain ranges of the globe every kind represented. We commence with one in which the arch is represented merely by a gentle swell of the rock-sheet, and the trough by an answering shallow depression, the two shading into each other in an area of contrary flexure. From this type we pass insensibly to others in which we see that the sides of the common limb or septum are practically perpendicular. From these we pass to folds in which the twisted common limb or septum overhangs the vertical, and so on to that final extreme, where the arch limb has been pushed completely over on to the trough limb, and all three members, as in our notebook experiment, are practically welded into one conformable solid mass.

Although the movements of these mountain folds are slow and insensible, and only effected in the course of ages, so that little or no evidence of the actual movement of any single one of them has been detected since they were first studied, yet it is perfectly plain that when we regard them collectively, we have here crust folds in every stage of their existence. Each example in itself represents some one single stage in the lifetime of a single fold. They are simply crust folds of different ages. Some are, as it were, just born; others are in their earliest youth. Some have attained their majority, some are in the prime of life, and some are in the decrepit stages of old age. Finally, those in which all three members—arch limb, trough limb, and septum—are crushed together into a conformable mass, are dead. Their life of individual movement is over. If the earth pressure increases, the material which they have packed together may of course form a passive part of a later fold, but they themselves can move no more.

In many cases, due partly to the action of longitudinal pressures, tho septum becomes reduced to a *plane* of contrary motion, namely—the over-fault, or thrust-plane, and the arch limb and the trough limb slide past each other as two solid masses. But here we have no longer a fold, but a fault.

We see that every mountain fold commences first as a gentle alternate elevation and depression of one or more of the component sheets of the geological formations which make up the earth-crust. This movement is due apparently to the tangential thrusts set up by the creeping together, as it were, of those neighboring and more resistant parts of the earth-crust which lie in front of and behind the moving wave. Yielding slowly to these lateral thrusts the crest of the fold rises higher and higher, the trough sinks lower and lower, the central common limb or septum grows more and more vertical and becomes more and more strained, sheared and twisted. As this middle limb yields, the rising arch part of the fold is forced gradually over on to the sinking trough, until at last all three members come into conformable contact and further folding as such is impossible. Movement ceases, the fold is dead.

We see also from our note-book experiment that the final result of the completion of the fold is clearly to strengthen up and consolidate that part of the crust plate to the local weakness of which it actually owed its origin and position. The fold has by its life-action theoretically trebled the thickness of that part of the earth-plate in which its dead remains now lie. If the lateral pressure goes on increasing and the layers of the earth-crust again begin to fold in the same region, the inert remains of the first fold can only move as a passive part of a newer fold: either as a part of the new arch-limb, the new trough-limb, or the new septum. As each younger and younger fold formed in this way necessarily includes a more resis ant, and therefore a thicker, broader, and deeper sheet of the earth-crust, we have here the phylogenetic evolution of a whole family of crust folds, each successive member of which is of a higher grade than its immediate predecessor.

But it very rarely happens that the continuous plate in which any fold is imbedded is able to resist the crust creep until the death of the first fold. Usually, long before the first simple fold is completed, a new and parallel one rises in front of it on the side of the trough limb, and the two grow, as it were, henceforward side by side. But the younger fold, being due to a greater pressure than the older, must of necessity be of a higher specific grade, and the two together form a generic fold in common.

Our present mountain systems are all constituted of several families of folds, all formed in this way, of different gradations of size, of different dates of origin, and of different stages of life evolution; and in each family group the members are related to each other by this natural genetic affinity.

Sometimes the new folds are formed in successive order on one side of the first fold, and then we have our unilateral (or so-called unsymmetrical) mountain groups, like those of the Jura and the Bavarian Alps. Sometimes they are formed on both sides of the original fold, and then we have our bilateral (or so-called symmetrical) ranges, like the Central Alps. In both cases the septa of the aged or dead folds are of necessity all directed inwards towards the primary fold. If, therefore, they originate only on one side of the fold, our mountain group looks unsymmetrical, with a very steep side opposed to a gently sloping side. If they grow on both sides of the original fold, we have the well-known "fan structure" of mountain ranges. In this case the whole complex range is seen at a glance to be a vast compound arch of the upper layers of the earth-crust, keyed up by the material of the dead or dying folds, which by the necessities of the case constitute mighty wedges whose apices are directed inwards towards the centre of the system. But a complete arch of this kind is in reality not a single fold, but a double one, with a septum on both sides of it; and it requires two troughs, one on each side of it, as its natural complement. The so-called unsymmetrical ranges, therefore, which are constituted merely of arch limb, trough limb, and septum, are locally the more natural and the more common.

It is clear that in the lifetime of any single fold its period of greatest energy and most rapid movement must be that of middle life. In early youth the lateral pressure is applied at a very small angle, and the tangential forces act therefore under the most disadvantageous circumstances. In the middle life of the fold the arch limb and the trough limb stand at right angles to the septum, and the work of deformation is then accomplished under the most favorable mechanical conditions and with the greatest rapidity. That is to say, the activity of the fold and the rate of movement of the septum, like the speed of the storm wind, vary directly as the gradient.

In our note-book experiment we observed that little or no change took place in the arch limb and trough limb, while the septum became remarkably sheared and twisted. The same is the case in nature, but here we have to recollect that these moving mountain folds are of enormous size, indeed actual mountains in themselves. These great arches, scores of miles in length, thousands of feet in hight and thickness, must of necessity be of enormous weight, capable of crushing to powder the hardest rocks over which they move, while the thrust which drives them forward is practically irresistible. It is plain, therefore, that while the great arch limb and the trough limb of one of these mighty folds move over and under each other from opposite directions, they form together an enormous machine, composed of two mighty rollers, or millstones, which mangle, roll, tear, squeeze, and twist the rocky material of the middle limb or septum, which lies jammed in between them, into a laminated mass. This deformed material, which is the characteristic product of the mountain-making forces, is, of course, made up of the stuff of the original middle limb of the fold; and whether we call it breccia, mylonite, phyllite, or schist, although it may be composed of sedimentary stuff, it is certainly no longer a *stratified* rock; and though it may have been originally purely igneous material, it is certainly no longer *volcanic.* It is now a manufactured article, made in the great earth mill.

These mountain folds, however, are merely the types of folds and wrinkles of all dimensions which affect the rock formations of the earth-crust. Within the mountain chains themselves we can follow them fold within fold, first down to formations, then to strata, then to laminæ, till they disappear at last in microscopic minuteness beyond the limits of ordinary vision. Leaving these, however, for the moment, let us travel rather in the opposite direction, for these mountain folds are by no means the largest known to the stratigraphical geologist. Look at any geological section crossing the continent of North America, and it will be found that the whole of the Rocky Mountain range on its western side and the Alleghany range on the east are really two mighty compound geological anticlines, while the broad sag of the Mississippi basin is actually a compound geological syncline made up of the whole pile of the geological formations. That is to say, the continent of North America is composed of a pair of geological folds, the two arches of which are represented by the Rockies on the one side and the Alleghanies on the other, while the intermediate Mississippi syncline is the common property of both. Here, then, we reach a much higher grade of fold than the orographic or mountain-making fold, viz., the plateau-making fold or the semi-continental fold, which, because of its enormous breadth, must include a very much thicker portion of the earth-crust than the ordinary orographic fold itself.

But where must be the real middle limbs of these two American folds —those septal areas where most work is being done and the motion is greatest?

Taught by what we have already learned of the mountain wave the answer is immediate and certain. They must be on the steeper sides of each of the two folds, namely, those which face the ocean. How perfectly this agrees with the geological facts goes without saying. It is on the steep Pacific side of the western fold that the crushing and crumpling of its rocks are the greatest. It is on the Atlantic side of the eastern fold that the contortion and the metamorphism of its rocks are at their maximum, while in the common and gently sloping trough of both folds, namely, the intermediate Mississippi valley, the entire geological sequence remains practically unmodified throughout.

Again, which of these two American folds should be the more active at the present day? Taught by our study of the mountain wave the answer again is immediate and conclusive. It must be that fold whose septum has the steeper gradient. Geology and geography flash at once into combination. The steeper Pacific septum of the western fold from Cape Horn almost to Alaska is ablaze with volcanoes, or creeping with earthquakes, while the gently inclined Atlantic septum of the eastern fold from Greenland to Magellan straits shows none, except on the outer edge of the Antilles, in the very region where the slope of the surface is the steepest. We see at a glance that the vigor of these two great continental folds, like those of our mountain waves, varies directly as the surface gradient of the septum.

But the geographical surface of North America, considered as a whole, is in reality that of a double arch, with a sag or common trough in the middle. We have seen already that this double arch must be regarded as the natural complement of the equally double Atlantic trough. Here, then, if the path of analogy we have hitherto so triumphantly followed up to this point is still to guide us, the basin of the Atlantic must be, not only in appearance, but in actuality, formed of two long minor folds of the same grade as the two that form the framework of America, but with their members arranged in reverse order. If so, their submarine septa ought also to be lines of movement and of volcanic action. And this is again the case. The volcanic islands of the Azores and St. Helena lie not exactly on the longitudinal crests of the mid-oceanic *Challenger* ridge, but upon its bounding flanks.

But we have not yet, however, finished with our simple fold. If we draw a line completely round the globe, crossing the Atlantic basin at its shallowest, between cape Verde and cape St. Roque, and continue it in the direction of Japan, where the Pacific is at its deepest, as the trace of a great circle, we find that we have before us a crust fold of the very grandest order. We have one mighty continental arch stretching from Japan to Chile, broken submedially by the sag of the Atlantic trough; and this great terrestrial arch stands directly opposed to its natural complement, the great trough of the Pacific, which is bent up in the middle by the mightiest of all the submarine buckles of the earth-crust, on which stand the oceanic islands of the central Pacific.

But if this be true, then the septum of all septa on our present earth-crust must cross our grandest earth fold where the very steepest gradient occurs along this line, and it must constitute the centre-point of the moving earth fold, and of greatest present volcanic activity. And where is this most sudden of all depressions? Taught once more by our geological fold, the answer is instantaneous and incontrovertible. It is on the shores of Japan, the region of the mightiest and most active of all the living and moving volcanic localities on the face of our globe.

But the course of the line which we indicated as forming our grandest terrestrial fold returns upon itself. It is an endless fold, an endless band, the common possession of two sciences. It is geological in origin, geographical in effect. It is the *wedding-ring* of geology and geography, uniting them at once and for ever in indissoluble union.

Such an endless fold, again, must have an endless septum, which, in the nature of things, must cross it twice. Need I point out to the merest tyro in these wedded sciences that if we unite the Old and New Worlds and Australia, with their intermediate sags of the Antarctic and Indian oceans, as one imperial earth arch, and regard the unbroken watery expanse of the Pacific as its complementary depression, then the circular coastal band of contrary surface flexure between them should constitute the moving master septum of the earth crust. This is the "Volcanic girdle of the Pacific," our "Terrestrial Ring of Fire."

Or, finally, if we rather regard the compact arch of the Old World itself as the natural complement of the broken Indo-Pacific depression, then the most active and continuous septal band of the present day should divide them. Again our law asserts itself triumphantly. It is the great volcanic and earthquake band on which are strung the Festoon islands of western Asia, the band of mount St. Elias, the Aleutians, Kamtchatka, the Kuriles, the band of Fusijama, Krakatoa, and Sangir. The rate of movement of the earth's surface doubtl ss everywhere varies directly as the gradient.

We find, therefore, that even if we restrict our observations to the most simple and elementary conception of the rock fold as being made up of arch-limb, trough-limb, and twisting but still continuous septum, we are able to connect, in one unbroken chain, the minutest wrinkle of the finest lamina of a geological formation with the grandest geographical phenomena on the face of our globe.

We find, precisely as we anticipated, that the wave-like surface of the earth of the present day reflects in its entirety the wave-like arrangement of the geological formations below. On the land we find that the surface arches and troughs answer precisely to the grander regional anticlines and synclines of the subterranean sedimentary sequence; and it may I believe, be regarded as certain that the submarine undulations have a similar or complementary relationship. We find in the new geology, as Hutton found in the old, that geography and geology are one. We find, as we suspected, that the physiognomy of the face of our globe is an unerring index of the solid personality beneath. It bears in its lineaments the characteristic family features and the common traits of its long line of geological ancestors.

Such, it seems to me, is an imperfect account of the introductory paragraphs of that great chapter in the new geology now in course of interpretation by geologists of the present day; and we have translated them exactly in the old way by the aid of the only living geological language, the language of present natural phenomena, and I doubt not that sooner or later the rest of this great chapter will be read by the same simple means.

I have confined myself to-day to the discussion of the characteristics of the simple geological fold as reduced to its most elementary terms of arch, trough and unbroken septum; for this being clearly understood, the rest naturally follows. But this twisted plate is really the key which opens the entire treasure-house of the new geology in which lie spread around in bewildering confusion facts, problems, and conclusions enough to keep the young geologist and other scientific men busily at work for many a long year to come.

Into this treasure-house I often wander myself, in the few leisure hours that I can steal from a very busy professional life; and out of it I bring now and again heresies that sometimes amuse and sometimes horrify my geological friends. As you have so patiently listened to what I have already said, perhaps you will permit me in a few final sentences to indicate in brief some of those novelties which I see already more or less clearly, and a few of those less novel points on which it appears to me that more light is wanted. My excuse is two-fold—first, to furnish material for work and controversy to the young geologists; and second, to obtain aid for myself from workers in other walks of science.

The account of the simple rock-fold I have already given you is of the most elementary kind. It presupposes merely the yielding to tangential pressure from front and back, combined with effectual resistance to sliding. But in the layers of the earth-crust there is always, in addition, a set of tangential pressures theoretically at right angles to this. The simple fold becomes a *folded fold*, and the compound septum twists not only vertically but laterally. On the surface of the globe this double set of longitudinal and transverse waves is everywhere apparent. They account for the detailed disposition of our lands and our waters, for our present coastal forms, for the direction, length, and disposition of our mountain-ranges, our seas, our plains, and lakes. The compound arch becomes a dome, its complementary trough becomes a basin. The elevations and depressions, major and minor, are usually twinned, like the twins of the mineralogist, the complementary parts being often inverted, and turned through 180° (compare Italy with the Po-Adriatic depression). Every upward swirl and eddy has its answering downward swirl. The whole surface of our globe is thus broken up into fairly continuous and paired masses, divided from each other by moving areas and lines of mountain making and crust movement, so that the surface of the earth of the present day seems to stand midway in its structure and appearance between those of the sun and the moon, its eddies wanting the mobility of those of the one and the symmetry of those of the other. In the geology of the earth-crust, also, the intercrossing of the two sets of folds, theoretically at right-angles to each other, gives rise to effects equally startling. It lies at the origin of the thrust-plane or over-fault, where the septal region of contrary motion in the fold becomes reduced to, or is represented by, a *plane* of contrary motion. It allows us to connect together under one set of homologies folds and faults. The downthrow side of the fault answers to the trough, the upthrow side to the arch, of our longitudinal fold; while the fault-plane itself represents the septal area reduced to zero. The node of the fault, and the alternation and alteration of throw, are due to the effects of the transverse folding.

These transverse folds of different grades, which affect different layers of the earth-crust differentially, account also for the formation of laccolites, of granitic cores, and of petroiogical provinces; and they enable us also to understand many of the phenomena of metamorphism.

Of the folds of the *third order* I shall here say nothing; but I must frankly admit that the primal cause of all this tangential movement and folding stress is still as mysterious to me as ever. I incline to think that it is due to many causes—tidal action, sedimentation, and many others. I cannot deny, however, that it may be *mainly* the result of the contraction in diameter of our earth, due to the loss of its original heat into outer space. For everywhere we find evidences of symmetrical crushing of the earth-crust by tangential stresses. Everywhere we find proofs that different layers of that crust have been affected differentially, and the outer layers have been folded the most. We seem to be dealing not so much with a solid globe as with a globular shell composed of many layers.

Is it not just possible after all that, as others have suggested, our earth is such a hollow shell, or series of concentric shells, on the surface of which gravity is at a maximum, and in whose deepest interior it is non-existent? May this not be so also in the case of the sun, through whose spot eddies we possibly look into a hollow interior? If so, perhaps our present nebulæ may also be hollow shells formed of meteorites; on the surfaces of these shells the fiery spirals we see would be the swirls which answer to the many twisting crustal septa of the earth. Our comets, too, in this case might be elongated ellipsoids, whose visible parts would be merely interference phenomena or sheets of differential movement.

In this case we have represented before us to-day all the past of our earth as well as its present. Uniformity and evolution are one.

Thus from the microscopic septa of the laminæ of the geological formations we pass outwards *in fact* to these moving septa of our globe, marked on land by our new mountain-chains, and on our shores by our active volcanoes. Thence we sweep, *in imagination,* to the fiery eddies of the sun, and thence to the glowing swirls of the nebulæ; and so outwards and upwards to that most glorious septum of all the visible creation, the radient ring of the Milky Way.

Prof. George Darwin, in his address to the section of mathematical and physical science at the meeting of the British Association at Birmingham in 1886, with all the courage of genius, and the authority of one of the sons of the prophets, acknowledged that it seems as likely that "meteorology and geology will pass the word of command to cosmical physics as the converse." Behind this generous admission I shelter myself. But I feel absolutely confident that long after the physicists may have swept away these provisional astronomical suggestions as "the baseless fabric of a vision," there will still remain in the treasure-house of the geological fold a wealth of abundant material for the use of the mathematician, the physicist, the chemist, the mineralogist, and the astronomer, of the deepest interest and of the highest value.

EDITORIAL COMMENT.

Geological Reminiscences of Rochester in 1892.

a—Geology at Rochester.
b—Excursion to the "Pinnacles".
c— " " " Niagara Quarries.
d— " " " Gorge of the Genessee.
e— " " Niagara Falls.
f— " " the Salt-well at Livonia.
g— " " Irondequoit Bay and Lake Ontario.

Apart from the papers and discussion the recent gathering of geologists at Rochester was noteworthy. Though Rochester is one of the large and old established cities of the Empire state, yet the American Association for the Advancement of Science had never before met there, and the recent gathering and its success are in great part due to the judgment and activity of Prof. Fairchild, of the university, aided by the local committee.

The region around Rochester is one of considerable geological interest and several of the special points were visited by members of the Society and of the Section during their stay. This part of the annual gathering seems to be assuming more and more prominence—a fact scarcely to be regretted. To most of the visitors as much advantage may be gained by seeing a new locality as by spending their time within four walls. Geology is an outdoor science and its successful propagation is likely to be successful in proportion as its study is prosecuted in the field. Possibly short excursions in the neighborhood of the place of meeting, preceded and accompanied with careful description and explanation, may form in time a regular part of the program both of the Geological Society and of the Section. Such excursions would be specially adapted to interest the younger members and to bring them into active work.

Be this as it may, however, the excursions were interesting and profitable parts of the Rochester meeting. One afternoon a party with Mr. G. K. Gilbert, a native of Rochester, as guide, went to the Pinnacle hills, about two miles from the city, and examined their structure as it was shown in a large gravel pit. Here could be seen stratified sand overlain by gravel and shingle—true northern drift—and this again by till laden with large and small stones, many of them smooth and striated. Great irregularity was seen in one place where the bedded material had been disturbed apparently soon after its deposition. Several slight faults with small downthrow to the northeast were visible at various points and at the northeast end all signs of stratification ceased and the hill consisted of a confused mass of gravel and sand overlain by till. Numerous large and unworn blocks of Niagara limestone were scattered through the hill and had been brought from the outcrop of the same stone at a much lower level a few miles off.

The visit formed the topic of an interesting discussion next morning, though some objection was raised by a few to this interruption of the program. Probably the objection can in future be obviated in such a case without causing difficulty.

Another excursion was made to the quarries in the western part of the city under the leadership of Prof. Arey of the high school, who has apparently collected more Niagara fossils from the region than any one else in the city who took part in the meeting. These quarries cover many acres of ground and the stone has been excavated to the depth of twenty feet or more. The Niagara is here a dark grey limestone yielding few fossils among which *Stromatopora concentrica* is by far the most abundant. All are in a bad state of preservation, existing as casts alone. The characteristic minerals were found in plenty or bought from the boys; such as dolomite, selenite and other forms of gypsum, blende, etc.

The excursion to Portage and Mt. Morris proved exceedingly pleasant and instructive. Running alongside of the beautiful gorge of the Genessee the geologists could not fail to be struck with the immense work that had been done by the river during post-glacial time. Miles of canyon, hundreds of feet in depth, passed in review as the country rapidly rose toward the higher table land of central New York. At the head of the gorge was seen the cutting-engine at work under the Erie viaduct in the form of the Upper Fall, which is continuing the task of excavation to the southward. A few miles lower down the Middle Fall, as a second cutter, is following suit and deepening the groove while the Lower Fall, hidden in the forest and accessible only with difficulty, is slowly coming up stream in the wake of the other two, and completing the work. Below these three follows a run of comparative peace until the river reaches Rochester and throws itself over the great Silurian escarpment where another series of falls exists and another consequent canyon is in course of excavation.

The party were received and hospitably entertained by the citizens of Mt. Morris at dinner, after which carriages were in waiting which took them to the winding and most picturesque part of the gorge about two miles from the town. Here a very fine view was obtained over the country. The Genessee has cut since the Ice-Age a serpentine groove through the shale several miles long where the cataracts once existed which have now receded up stream to Portage. The river here flows several miles to accomplish what in a straight line is only a short distance. At a point just above Mt. Morris it is proposed to erect a solid dam of masonry 130 feet high across the river and pond, back the water for eleven miles, forming instead of a canyon a winding narrow lake 150 feet deep at its lower end and gradually shoaling upward. The plan is intended to equalize the flow of the Genessee, holding back the water in floods and supplying more effective and constant water power to Rochester and other towns along its course. Its effect on the scenery of the valley may not be improving but in this utilitarian age few stop to consider this aspect of the undertaking. A hasty stop at the salt-works concluded the day's excursion.

Another party and a large one spent the day at Niagara chiefly to enjoy the scenery and the change. Here also they were well entertained, and the visit was highly appreciated, but the ground is very familiar to nearly all and any description would be superfluous for geologists.

The other Saturday excursions were intended chiefly for botanists and pleasure seekers. We need not say that they were well attended and enjoyed.

A special party, led by Prof. H. T. Fuller, afterwards made an excursion to the new shaft drilled for salt at Livonia. In spite of the extraordinarily low price at which salt is now sold there is apparently a profit in its manufacture as the works are being enlarged and extended in every direction.

Irondequoit bay and its preglacial valley and the beaches of lake Ontario were visited and investigated by special parties who chiefly made their own arrangements. Nothing but a visit can give adequate ideas of this monument of the Ice-Age standing in bold relief on the very edge of the Ontarian basin, and to glacialists few excursions could be more useful or interesting. But a lengthy description would be of little use and might even become tedious. The general features are familiar. The "ridge road" occupies the old sand beach under which lies a lower one of coarse shingle chiefly composed of Medina sandstone mingled however with northern drift. Below the last and entirely concealed by glacial deposits is the ancient buried cliff, of hight unknown, which once formed the southern bluff of the Ontarian valley before the lake existed. Heavy deposits of silt and of morainic matter fill the inlets up to the level of the ancient outflow point where the waters of the lake escaped when the present channel of the St. Lawrence was blocked. These facts and the lessons which they can teach of the varying hight of the water and possibly also of the land lent great interest to the various lake excursions and were to geologists exceedingly instructive. All, whether geologists or not, fully appreciated the kindness of their Rochester entertainers, and the aid kindly given them by several of the railway companies whose lines run to Rochester.

Ward's Natural Science Establishment.

Not the least among the attractions of Rochester to the geologists belonging to the Association was the establishment of Prof. Henry A. Ward. From a small beginning, thirty years ago, this museum factory has grown to immense size. The earliest collection made by its founder was purchased about twenty-eight years ago by the University of Rochester and now adorns its cases and supplies magnificent material for illustration. In few places can be found finer or larger specimens of some of the minerals there exhibited. Enumeration would be tedious, but the eye of even the cursory visitor, whether geologist or not, must be arrested by the splendid crystals of Cornish fluorite, Cinghalese graphite, blende and hæmatite from the north of England, and septaria of large size, cut and polished for ornamental purposes, from the upper Mesozoic beds of the coast of the English channel and from Mt. Morris, N. Y., while almost unique in its singularity and beauty is a large specimen of crystalline (?) anthracite in the form of curved blades of cone-in-cone from South Wales.

On the palæontological side of the collection may be seen one of the finest sets of European Ammonites on this continent, with large suites of fossils from various countries and from many different horizons, which are of immense value to the student for purposes of comparison.

At the time of the purchase little had been done in American geology outside of New York state. The treasures of the great West were unknown and the East was almost unexplored. Hence this collection and most of those made at a similar date were composed, in great part, of foreign material. But additions have since been made and are being made as the department grows, and American palæontology has now a fair representation. The whole collection has recently been rearranged by Prof. Fairchild, and is in excellent condition.

It was the gathering of the specimens now in the museum at the University of Rochester that started Prof. Ward on his career. From that day onward he has been engaged in the task of collecting. No labor, pains or expense has been spared in reason, and, we fancy, sometimes out of it, to increase the value of his stores, and now his museum and laboratories are unequalled in America and scarcely, if at all, surpassed in scale in the world. It is difficult to ask for specimens, excepting, perhaps, unique or almost inaccessible forms, without having them at once laid before you. The writer has tried, and speaks from experience. Prof. Ward has visited almost every part of the world in search of material and is often somewhere in foreign parts seeking what he may obtain by purchase or exchange. His aim is to get all material from the typical localities so as to insure authenticity. He visits these places and secures collectors whenever possible, often men who are poor in money but enthusiastic in their work. From these he receives consignments year after year, thus keeping up the intercourse and the engagement. In some cases he finds it necessary to advance the funds for an expedition in search of the material wanted, and it is pleasant to learn that very rarely has the confidence been betrayed.

Prof. Ward returned from a long tour of this kind during the meeting of the A. A. A. S., bringing with him or sending on great quantities (over 200 cases) of minerals and other supplies. Here was stibnite from a rich Japanese locality, only discovered lately, luxulyanite (schorlaceous granite) from the typical region at Luxulyn cove, Cornwall, and polished serpentine from the classic Lizard Head, slabs of flexible sandstone (itacolumite) from Brazil, large blocks of ripple-marked sandstone from the quarries at Berea, O., basaltic columns from the Giant's causeway, and large calcites from the old but seemingly almost exhausted beds of Iceland.

Add to these syenite from the original Egyptian quarries at Assouan, dolomite from the Tyrol, liparite from the Lipari isles and hundreds of slabs of polished marbles from most of the well known marble quarries of the old and new worlds.

All these, when received, are carefully studied, determined and mounted. Labels are printed for the minerals showing the name and locality, with formula of composition, crystalline system and the number assigned in Dana's "Mineralogy." It is needless to point out how much, by this care, the teaching value of the specimens is increased.

In this connection should be noticed a school collection containing 120 specimens, which is amply sufficient for elementary work in the hands of a good and competent teacher. Such a collection should be in every school in the country, above the lowest grade.

Prof. Ward's personal pet at present is his collection of meteorites of which he now has about 164 "falls." One of these from Queensland had cost, he said, $1,020, and another that fell in Canada, only weighing a few ounces, was destined for the Royal-imperial museum at Vienna, where Dr. A. Brezina wanted it as a type of a kind not yet possessed by that immense collection.

Money is evidently not the first consideration at Vienna in securing objects of scientific value.

The worth of a meteorite, Prof. Ward explained, is often in inverse proportion to its size, because, if large, there is abundance of the material for all, whereas if small it must be used economically. Large meteorites are usually sliced for purposes of study, and a small set of gang saws was slowly cutting its way through one of these bedded in plaster, in an adjoining workshop, at the rate of one-eighth of an inch a day.

Not a few of the most interesting meteorites have been modeled and are on sale together with imitations of many of the great and famous but unique gems of the world. These latter are mostly of glass and are exceedingly beautiful, while for purposes of illustration and of teaching they are, to all intents, as useful as real gems.

Another important element is a large collection of working material, which is sold by the pound for the use of students and chemists. This is sufficient to illustrate the chemical properties of the minerals; while for the optical and other physical properties other sets are kept in stock. These are purchasable at prices that render it possible to use them for class purposes. Ores, also, of all the common kinds are kept for the same uses.

One very important and interesting department which has been conceded to Prof. Ward by the U. S. Geological Survey, is the construction of models of many interesting and important regions, such as the Gorge of the Colorado, Ætna, Vesuvius, the Cliff-dwellings of New Mexico, etc. An excellent model of the Serpent mound in Ohio was constructed during the meeting for the illustration of an address by Prof. Putnam before the Section of Anthropology.

The value of this kind of work is not at all appreciated at present by teachers at large. Only the few can see its helpfulness. But we hope the day is not very far distant when geography as a science will take its proper place in education—when the teaching of this subject will cease to be a mere burlesque, a memory task of names and details, and become, as it can be and should be, one of the most interesting and useful of all our youthful studies. Then will our educators awaken to the value, or rather, the necessity of such helps as these, and relief maps and globes will be as much things of course in the school-room as they are in the schools of Switzerland and of Germany.

But time would fail to tell of the many objects of interest that can be found in this museum, and we must limit ourselves to things geological.

One peculiar feature in this collection, original with Prof. Ward, who himself once held the professorship of natural science in Rochester University, is the collection illustrating geological phenomena, many fine specimens of which may be seen in the University Museum. Mud-cracks, stylolites, cone-in-cone, fulgurites or lightning tubes formed in sand, lavas of many kinds, dendrites, volcanic bombs, folded gneiss, etc., are all illustrated by abundant and excellent specimens. Add to these the collection of lithological specimens from the original localities, well labeled and showing on the back the geological section from which they each came, and its exact horizon in the section, and it is easy to see the great labor that has been spent in the preparation and elaboration of the material and its adaptation to the purpose of instruction.

Prof. Ward is naturally full of experiences. No man could go about the world so far and so often as he has been and on such an errand, without meeting with these. A mass of "grès lustré" was snatched from the bank of the Uruguay during a momentary stop of the river steamer, hauled on board and saved, to the astonishment of the fellow-passengers who came to the usual conclusion in regard to this "crank." The pumice gatherers of the Lipari isles laughed with undisguised contempt at the "fool" who drove down to the shore mules laden with obsidian, "worthless stuff" and neglected the commercially salable pumice.

Many of the museums of this country have been enriched by the labors of Prof. Ward, notably the museum of Comparative Zoology at Cambridge, where are several almost unique skeletons of the gigantic fossil mammalia, especially those from the wide pampas of Argentina, whose Tertiary gravels have yielded so many huge fossil sloths, etc., since the time when Darwin visited that country and made the world aware of the wonderful treasures that it contained. The Cambridge museum possesses *Mylodon*, *Glyptodon*, *Lestodon*, *Skelidotherium* and *Toxodon*, the last secured for Agassiz by a costly, urgent telegram sent by Prof. Ward from Buenos Ayres; $5,000 purchased the treasure in spite of the law against the exportation of these fossils, which was engineered through the Argentine Legislature by the well known geologist, Burmeister, then curator of the museum at Buenos Ayres. Forgetting the cosmopolitan generosity that should characterize science, he descended into the field of politics and attempted to exclude the students of other nations from the advantages which South America possessed, but could only imperfectly use. Fortunately, this selfish law never was, and perhaps could not be enforced. In the wholesale exportation of bones that was continuously going on for the manufacture of phosphates it was not to be expected that the custom-house officials could distinguish those of *Megatherium* and *Skelidotherium* from the more common place bones of *Bos* and *Equus* or perhaps of *Homo*, even had they wished so to do.

It is a treat to go through the museum with the professor when he is, as now and then happens, disengaged for a short time and to listen to the reminiscences suggested by this or that specimen. A fine piece of crokidolite elicited the story of a visit to Griqualand, the only known locality for the mineral, and a prowling excursion to the stone kraals of the natives with hammer in hand. Selecting those that contained the mineral as discovered by striking off a chip, the naturalist (what the Griquas call him is of no consequence here) pulled down the fence, took out the slab of crokidolite and either built up the wall again or left it for the owner to restore, as seemed to him advisable in regard to the future.

A portion of a basaltic column recalled a visit to the celebrated Giant's causeway, where in the chalk underlying the basalt, some magnificent specimens of Ventriculites (paramoudras) were secured by sending a man with a wagon through the country to beg or to buy them, as the case might be, from the country-folk, by whom they are used as posts or ornamental stones and for a variety of other purposes. One of these stood eight feet high in the chalk pit where it was found, and another now in Rochester and almost perfect, measures three feet.

Not the least debt which the geologist or the naturalist in general owes to Prof. Ward is one for the generosity with which he is willing to allow students to consult his specimens for purposes of comparison and of work. In few places can a better opportunity be found because the specimens are not usually mounted and set for purposes of show so that they cannot be handled, but they are in the rough, natural condition. Ask for one and in a minute the creature lies before you and you can examine almost every part of its structure inside and outside. In this way invaluable assistance may often be obtained by a worker who is unable to buy or perhaps, in consequence of their size, unable to keep the bulky specimens which he nevertheless desires to consult or to compare.

All this fails to give more than a scanty account of the treasures that the geologist can see at Rochester, and no mention has been made of other lines of study in which equally rich stores of material are kept. Ornithology, ichthyology and all the branches of zoölogy including human anatomy are comprehensively represented, and from a whale to a lancelet, from a humming-bird to an eagle, the museum is able to meet at once almost any call that may be made upon it. Ward's Natural Science Establishment is the Mecca for the American geologist and naturalist and a pilgrimage there is a sure profit and a joy.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

An Introduction to the study of the Genera of Paleozoic Brachiopoda. Part I. By JAMES HALL, assisted by JOHN M. CLARKE, Albany, New York, 1892. The work before us is the first part of Vol. VIII, Paleontology of New York. In this and the succeeding volume, which will be part two of Vol. VIII, Paleontology of New York, the veteran paleontologist of America designs to set before the student the present knowledge of the genera of that most common and most interesting group of fossils, the *Brachiopoda.* Necessarily the discussions and illustrations of these volumes are limited to Paleozoic brachiopods. As usual, the class *Brachiopoda* is divided into two orders, and for these the author uses the simple and convenient terms proposed by professor Huxley, the *Inarticulata* and the *Articulata.* To the definition and general discussion of the genera of the *Inarticulata* the author devotes 183 pages; while 13 plates are occupied by generic illustrations of the same group. The remaining portions of the volume, about 170 pages and 29 plates, are given to the forms usually referred to the three closely related families, *Orthidæ*, *Strophomenidæ* and *Productidæ.* The spire-bearing brachiopods, the *Rhynchonellidæ*, *Pentameridæ* and *Terebratuloid* forms, will be discussed in the second part of the volume. No attempt is made to arrange the genera either of the *Articulata* or *Inarticulata* in groups having the rank of zoological families.

The manner in which the author treats the genus *Orthis* will illustrate the method of the work in general. We have first, in chronological order, references to publications, particularly those of American authors, in which the genus is recognized. As a bibliography this feature of the work will prove of great value to students. Following the bibliography is a *diagnosis* of the genus. Variations in the external and internal characters of forms heretofore referred to the genus are discussed. The original type is considered, *O. callactis* and *O. calligramma* being selected from the species cited by Dalman as the only available types of the genus. The most common American form of the same type is *O. tricenaria.* Limiting the genus *Orthis* to such forms, there remains a vast assemblage of heterogeneous species, that have been referred to *Orthis* by various authors, to be disposed of in some other way. These are distributed among a number of genera, for a large proportion of which new names are proposed. For example we have *Plectorthis* to include the group of *O. plicatella*, *Dinorthis* for the group of *O. pectinella*, *Plæsiomys* for the group of *O. subquadrata*, *Hebertella* for the *O. sinuata* group, *Orthostrophia* of which *O. strophomenoides* is the type, *Platystrophia* for the group including *O. biforata*, *Heterorthis* to include *O. clytie* and its relatives, *Bilobites* for *O. biloba*, *Dalmanella* for the group resembling *O. testudinaria*, *Rhipidomella* for the group resembling *O. michelini*, *Schizophoria* for the group of *O. resupinata*. *Orthotichia* for *O. ? morganiana*, and *Enteletes* to include the species best known in America as *Syntrielasma hemiplicata.* After some further general discussion of this group we find a list of species that should be included under each of the generic names. There is also a tabular arrangement showing the geological range of each of the generic subdivisions. Only a few of the old genera afford opportunity for such extensive subdivision as *Orthis*.

The genus *Strophomena* is limited to the forms agreeing in structure with that recognized by de Blainville and Defrance as the *S. rugosa* of Rafinesque. As so limited it would include such concavo-convex species as have been, in recent paleontological literature, referred to *Streptorhynchus planumbona*, *S. filitexta*, etc.; while the *Strophomena alternata*, that usually holds an honored place among the earliest possessions of the embryonic paleontologist, is not a *Strophomena* at all, but must hereafter be paraded under the new generic name of *Rafinesquina.* The rigid application of the rules of nomenclature doubtless requires such changes, but the unsettling of long established terms is something always to be deplored. It would certainly be of great advantage to the taxonomic sciences, if a name, once in use and generally recognized as having a definite application, could be retained by the action of some "statute of limitation," notwithstanding the fact that indiscreet enthusiasts, rummaging in the dusty corners of oblivion, may bring to light some long forgotten name that had once been applied to the same thing.

For *Strophodonta* the present work revives the original and more correct form of *Stropheodonta.* The generic name, *Mimulus*, proposed by Barrande in 1879, and used on page 272 of the present volume, is inadmissible according to strict rules of nomenclature, since *Mimulus* has long been employed to designate a genus of labiate plants.

The work before us represents an inconceivable amount of pains-taking labor. The determination of the internal characters of the multitudinous species of Paleozoic brachiopods is something from which persons less enthusiastic and less gifted than the eminent author might well shrink. The work has been in hand more or less continuously for more than twenty years. That it is at last practically completed is something for which professor Hall deserves to receive the thanks and congratulations of paleontologic students.

The fulness with which each genus is illustrated adds incalculably to the value of the volume.

Development of the Brachiopoda. Part I. Introduction. (Am. Jour. Sci., vol. XLI, 1891, pp. 343-357, one plate.) *Part* II. *Classification of the Stages of Growth and Decline.* (Ibid. vol. XLIV, 1892, pp. 133-135, one plate.) By CHARLES E. BEECHER.

The object of these papers is to apply to the Brachiopoda "the law of morphogenesis as defined by Hyatt." No one of the classifications heretofore proposed is established upon fundamental principles but all are based on one set of secondary characters for certain groups and another set for other sections. The Brachiopoda, until 1883, had only been divided into two sections, the Lyopomata and Arthropomata of Owen, or the Inarticulata and Articulata of Huxley. When we consider that there are about 5,000 known species of brachiopods, arranged in over 270 genera, occurring in the oldest undoubted fossiliferous rocks and down to the present time, it certainly seems as if the class should be capable of further separation into large groups or orders besides those based upon the presence or absence of an articulating process. In that year, Dr. Waagen in his great work on the Brachiopoda of the Salt Range of India, further divided each section into three suborders. While this classification brought together, more or less correctly, families having relations to each other, yet no far reaching attempt was made to show the genesis of the class in the application of the principles of phylogeny and ontogeny. In the above mentioned papers Dr. Beecher has applied the "principles of growth; acceleration of development; mechanical genesis and geologic sequence of genera and species." The development of ancient species in their adult condition represents nealogic (youthful) or nepionic (young) stages of later forms.

The first or embryonic shell is alike in all Brachipoda, except where modified by accelerated development, it having been observed by the author in about forty genera, representing nearly all the leading families of the class. This, the first shell stage, he has termed the "protegulum" and is homologous with the "protoconch" of Owen in cephalopods and gastropods, and the prodissoconch of Jackson in pelecypods. The protegulum is "corneous and imperforate, semi-circular or semi-elliptical in outline, with a straight or arcuate hinge line, and no hinge area." The "prototype preserving throughout the development the main features of the protegulum, and showing no separate or distinct stages of growth" is found in the early primordial *Obolus labradoricus*

Billings, which has been referred to *Kutorgina* by authors. This species is shown to be generically distinct from *Kutorgina cingulata*, and for shells of that type the term *Paterina* is proposed. The protegulum is usually "paterina-shaped," yet in *Orbiculoidea* and *Discinisca* it is modified by accelerated growth "becoming more circular, and with shorter and more arcuate hinge in the ventral valve."

The author then explains in a clear and concise manner the "modifications from acceleration; differences in the valves and genesis of form" all of which is of the greatest importance to biologists and paleontologists. The "types of pedicle openings" are then considered, of which there are four, and these are shown to be of general application to all brachiopods. Lyopomata and Arthropomata are each divided into two orders. The first into *Atremata*, in which the pedicle "in all stages of growth emerges freely between the two valves, the opening being more or less shared by both," and *Neotremata*, where the pedicle is "more or less surrounded by progressive nealogic growth posterior to the initial hinge." The Atremata contain *Obolella*, *Trimerella*, *Lingula*, etc., while the Neotremata have such genera as *Discina*, *Acrotreta*, *Trematis*, *Crania*, etc. The Arthropomata are divided into *Protremata* and *Telotremata*. The pedicle in the former "is enclosed in early nepionic stages by shell growth; posterior covering (pseudo-deltidium) retained at maturity, or resorbed or abraded in nealogic stages, so that the pedicle protrudes between the two valves." Types of this order are *Orthisina*, *Strophomena*, *Productus*, *Orthis*, *Pentamerus*, etc. The Telotremata are distinguished in that the "pedicle opening [is] shared by both valves in nepionic stages, usually confined to one valve in later stages, and becoming more or less limited by two deltidial plates in ephebolic stages." This order contains the Rhynchonellidæ, Spiriferidæ and Terebratulidæ. These four orders are again divisible into natural suborders, and to these the majority of the names proposed by Waagen will be applicable.

Part II. treats of the "classification of the stages of growth and decline." The author gives in a condensed manner all the known embryonic and larvel stages of brachiopods from the ovum to the first shell stage. Of these there are six for which he adopts the terminology of Hyatt, and gives of each one or more illustrations. For comparison with the brachiopode four figures of embryonic stages of *Spirorbis borealis* are added, but the author says "it is not intended by this to indicate a close relationship with the chætopods, for the writer is inclined to accept the opinion of Joubin, that the brachiopods constitute a distinct and independent class."

The larval and later stages of *Thecidium*, as given by Kovalevski, are shown by Dr. Beecher to be genetically related to the Strophomenidæ rather than with the Terebratulidæ, to which the family Thecidiidæ is usually referred. Heretofore the Protremata, or strophomenoids, have been regarded as extinct with the close of the paleozoic age, but now this order is known to have lived from its inception up to the present time.

Much value, heretofore, was not placed on the nature of the covering to the pedicle opening, or *delthyrium*, as it has recently been termed by Prof. Hall, whether it is of one piece, the "deltidium," or composed of two pieces, the "deltidial plates." It is here shown "that the deltidium in all species possessing it (the Protremata) is an embryological, or nepionic feature, which may or may not continue to the ephebolic period; while the deltidial plates in other brachiopods (the Telotremata) appear later during the nealogic and ephebolic period, or may never be developed." The deltidium "is a shell growth from the dorsal side of the body [in the typeembryo stage] which afterwards becomes attached to the ventral valve, and is then considered as belonging to it," while the deltidial plates first commence to grow out from each side of the delthyrium during nealogic growth, and are secreted by the ventral mantel lobe; a fundamental difference.

The presence of a dorsal anal opening in the Lyopomata and its absence in recent Arthropomata the author admits is difficult to explain, its solution depending "upon whether the class is to be considered as progressive or degraded." In Silurian, Devonian and Carboniferous deposits forms occur belonging to the Protremata and Telotremata in which there has been observed a dorsal foramen, the "visceral foramen" of authors. "This character," he says, "is evidently in no way connected with the pedicle opening, but points to the existence, in the early articulate genera of an anal opening dorsal to the axial line, as in the recent Crania. * * * In reference to this character and the obsolescence of the eyes the class must be viewed as retrogressive since paleozoic time. * * * Progressive in concentration of posterior elements, expansion of anterior elements, and limitation of pedicle opening to one valve."

The post-embryonic stages are then defined, also giving examples and figures of the "nepionic [young], nealogic [youthful], ephebolic [mature], and geratologic [old age] periods."

"Another aspect of growth and decline is manifest when the size of individuals and the chronological history of the groups are taken into consideration. Each genus and family began with small representatives, and rapidly developed the more radical varieties of structure. Then came the culmination and final reduction in size, with abundance of geratologous and pathologic forms. * * * The culmination of geratologous growth results in the reversion of the animal to its own nepionic period and is called the nostologic stage." Among clinologic and nostologic genera are mentioned *Cistella*, *Gwynia*, *Atretia* and *Platydia*, which have lost many of their adult progressive ancestral features and, therefore, represent early stages of growth in other modern species.

Annual Report of the Department of Mines and Agriculture, New South Wales, for the year 1891. This report presents, in a very admirable way, the results of mining operations in New South Wales for the annual period it covers. In the case of some of the valuable minerals there are comparative tables giving the annual output year by year from 1865 to 1891. The value of the yearly product of minerals by the colony is between six and seven millions sterling. The total value of minerals produced to the close of 1891 exceeds ninety-three and a half millions. The value of silver and silver ores produced in 1891, exceeds three and a half millions, a value greater than all the rest of the minerals together. Coal comes next in importance, its value for the year being about one and three-fourths millions. Tin was produced to the value of £271,412, while of iron the value amounted only to £36,101. Bituminous and kerosene shales have a value in the colony and are mined and utilized to the amount of more than 40,000 tons. Indeed some of the coals, if we may judge from the analyses, are little better than the product known as shales. Of the coal, however, which is all of Mesozoic age, more than 4,000,000 tons were raised during the year covered by the report.

There are detailed reports on the several mines and mining districts. There are tables showing number of men employed in mining, and number of accidents that occurred during the year. Besides the subjects usually found in mining reports we find a *Water Conservation Report*, which refers to public watering places established on the main stock routes of the colony for the convenience of traveling stock. All the watering places, with a few exceptions, are under the direction of caretakers who collect fees for the privilege of watering animals at so much a head. Some of these places are leased; in the case of those not leased, the fees are forwarded to the treasury. There are also reports from the *Superintendent of Caves*, a public office unknown in America.

In an article in the fifteenth volume of the *Journal of the Cincinnati Society of Natural History*, Mr. J. F. James continues his summary of the Palæontology of the Cincinnati Group, enumerating and reprinting descriptions of the species of Stromatopara, Stromatocerium and Beatricea, also those of Columnaria among the Actinozoa. The paper will be continued.

The same writer also discusses the preservation of plants as fossils, showing how the mere impression of a leaf or other organ may in some cases be preserved, though not a vestige of the actual substance may remain to be fossilized.

Mr. Whitman Cross, in the *American Journal of Science* (July, 1892), describes a series of strata in Colorado which fill a part of the gap existing between the top of the Laramie (Cretaceous) and the lowest recognized Eocene beds. "The facts of stratigraphy and lithology show that in Colorado the great conformable series of Cretaceous formations ended with the coal-bearing Laramie strata. Deposition plainly ceased in this region because continental elevation, which had long been in progress, finally caused the retreat of the Laramie seas." "When sedimentation again began it was in comparatively small lakes or seas. In the pebbles of the Arapahoe beds is the record of the slow erosion of 14,000 feet of strata, from the Laramie down to the red beds of the Trias."

Then followed volcanic outbursts over a large area, not however necessarily requiring a very long era for their occurrence. The thickness of the Middle Park beds, the lower half of which is in great part volcanic, is 6,000 feet, indicating considerable subsidence during their formation.

The author then discusses the evidence for the age of the beds that he has described, and says that the arguments drawn from the fossil vertebrates are not conclusive in either direction, because the age of the beds in which the types were found has not itself been decided. Hence, to employ them as a test of the age of other strata elsewhere, is in fact reasoning in a circle.

Mr. C. S. Prosser contributes to the *Proceedings of the Rochester Academy of Science* a paper on the thickness of the Devonian and Silurian strata of Western New York, along the line of the Genessee river, which is of present interest as relating to the ground of the meeting of the American Association. He briefly sums up the various attempts in the early days of American geology to correlate the strata and to determine their thickness, and then from a careful comparison of four well kept borehole records, deduces the mean and actual thickness of the rocks. "Taking", he says, "the sum of these maximum estimates, we have a series of rocks 6,810 feet in thickness between the base of the Olean conglomerate and the top of the Archæan(?). The same section compiled from a series of well-records gives a thickness of 7,100 feet. At Rochester the thickness from the top of the Medina to the top of the Trenton is 1,756 feet, and at Wolcott 1,720 feet. Leaving out of consideration all well-records, a conservative estimate of the thickness of this series of rocks at Rochester, based on published data, would be from 1,250 feet to 1,500 feet.

CORRESPONDENCE.

Some Remarks on professor Henry S. Williams' Address Before Section E., A. A. A. S., at Rochester, N. Y., August, 1892; on "The Scope of Palæontology and its Value to Geologists," in the American Geologist for September, p. 148.—In a letter printed in the American Geologist for January, 1889, p. 61, I have given facts at variance with professor Williams' expressed opinions on nomenclature and classification of the American Devonian; which have been accepted and made use of, by him, in his paper, entitled "Correlation Papers—Devonian and Carboniferous" (*Bull. U. S. Geol. Surv.*, No. 80, 1891); and now I hope he will receive, as fairly, some important facts touching the real history of the discovery and use of paleontology in geological science, which are in a measure overlooked in his paper before the American Association for the Advancement of Science.

After the first paper of Cuvier, read before the Institut National, of France, the 1st pluviose an IV of the Republic, and published in 1800, in which he spoke for the first time of the existence of an entire fauna, anterior to the existing one, stratigraphy was begun in earnest round

Paris by Cuvier himself, associated with Alexander Brongniart. In his autobiography, Cuvier says, "From 1804 to 1808, the singularity of the animals, of which I have discovered the bones at Montmartie, made me desire to know with more details the geology of the environs of Paris. My friend Brongniart joined me in this work. I discovered [after many combinations and comparisons of sections of quarries and butts] the uniformity of our strata; and it was I who discovered also, in the forest of Fontainebleau, the immense layers of fresh water deposits intercalated between marine beds. We published the résumé of our researches in the spring of 1808." The title of that important memoir is: *Essai sur la géographie minéralogique des environs de Paris.*

A contemporary and the author of the first geological map of France, the celebrated geologist, d'Omalius d'Halloy, says of this work: "As regards geology, it is the most important of the century, because it contains the first record of the revolution which has created the present statutes of that science; that is to say, it first applied paleontology to the study of the crust of the earth."

In 1810 Alexander Brongniart and Cuvier published a second and most important edition of their memoir, in which is found, for the first time, lists of fossil remains special to each bed or group of strata.

William Smith, after many years of researches, published, in June, 1816, his masterly work for English geology of: *Strata Identified by Organized Fossils*; followed next year by: *Stratigraphical System of Organized fossils—explaining their use in identifying the British strata.* Strata Smith, as he was nicknamed by his contemporaries in England, seems to have discovered, as far back as 1795, that each stratum was characterized by special fossil remains; and there is no doubt, that in 1799, he wrote a tabular view showing the *order of the strata and their imbedded organic remains in the vicinity of Bath.* Unfortunately it remained unpublished until his nephew, John Phillips, published his *Memoirs of William Smith* in 1844; so it cannot be used in a question of priority.

At that time England and France were involved in constant wars, and Cuvier, Brongniart and Smith made their discoveries, completely in ignorance of one another's works and researches. Smith, in his 4to volume of 1817, quotes at p. IV of the introduction, among the works that he has consulted: *Cuvier—Geographie Minéralogique des environs de Paris*; but maintained that "The first written account of this discovery was circulated in 1799."

But if the discovery was simultaneous in England and in France, its great value and full importance was shown through Cuvier and Brongniart's published works on *Comparative Anatomy; Recherches sur les ossements fossiles*, and the *géographie mineralogique des environs des Paris*, from 1800 to 1812; years before any of William Smith's publications.

Until 1819 nothing was attempted in the way of synchronism and assimilation of formations of strata at great distances, in using fossil remains only; when Alexander Brongniart read a report before the Academy of Science, showing remarkable similarity in each formation or *terrain* "dans les pays les plus éloignés, sous les latitudes et sous les méridiens les plus différentes." But, as he says, it was only a first draft, too imperfect for publication; and it was only in 1821 that he published in the *Annales des Mines*, his masterly paper: *Sur les caracteres zoologiques des formations.* From that day, *Comparative paleontology* was founded; and the first application of the principles and methods developed in the memoir was on the celebrated fossil localities of the "Montague des Fiz vallée de Servoz," Savoie, at the foot of the Mont Blanc, and "La Teste du Rhône," near Geneva, where Brongniart recognized by the fossil remains the identity of these formations with the *Glauconie crayeuse* of Paris basin and the *Gault* and *Green Sand* of England.

I have enjoyed the privilege of knowing personally and meeting often Alexander Brongniart during the two last years of his life, in 1846 and 1847. He kept all his enthusiasm for parallelism and synchronism of formations at great distances by means of fossil remains, and followed with close attention all the work done in that direction by the younger generation of geologists, who then began to be divided into two branches, the geologist without any other qualification and the stratigraphic paleontologist. Brongniart saw the exaggeration of some in too great generalization of his principles, and was adverse to it. Alcide d'Orbigny more specially frightened him with his great number of successive creations of faunas; and I must add that he was far from accepting the many great universal cataclysms insisted upon by Elie de Beaumont. Brongniart was more in harmony with the views of Deshayes, who truly established the three great divisions of the Tertiary strata, according to the faunas, in working out his great and most important publication: *Description des coquilles fossiles des environs de Paris*, 1824-31.

Lyell did not work out the Tertiary fossils, he only used Deshayes' researches and applied to the result arrived at a good nomenclature, calling the Tertiary formations: Eocene, Miocene and Pliocene. When Lyell came to Paris, in 1823, he knew next to nothing of the Tertiary strata, and it was there and then that Constant Prévost showed him all the divisions and classification, by great groups, and bed by bed, as they have been established by the joint efforts and discoveries of Cuvier, Brongniart, Deshayes and Prévost himself.

There is no doubt that the school of paleontologists, which contained such great observers as de Buch, Agassiz, d'Obigny, Quenstedt, etc., did go too far in their generalization. Deshayes never accepted their extreme ideas, and always maintained passage of forms and even sometimes of species from one formation to another.

I shall not refer to many points of geographical zoology and evolution of forms, more or less appreciated in professor Williams' paper, but shall only say that speaking of "The scope of paleontology and its value to geologists" without quoting the magnificent and grand discoveries and papers of Barrande, seems a very extraordinary forgetfulness, and equally so is a complete absence of reference to the discoverer of the method and principle, Alexander Brongniart. Even reference to the works of those who have made use,with great success, of Brongniart's methods in America, is very incomplete and partial, for some of the first and best investigators of the United States, as: Dr. Samuel Morton, Vanuxem, Conrad, Emmons and Leidy, are entirely passed over, in Mr. Williams' address.

The use of paleontology for assimilation, synchronism and classification in geology, requires special talent, good judgment and an amount of practical knowledge which are seldom combined in one man; and this explains why so many observers fail to give good correlation and exact classification, notwithstanding their long and patient researches in paleontology.

Jules Marcou.

Cambridge, Mass., Sept. 22, 1892.

PERSONAL AND SCIENTIFIC NEWS.

The Sixth International Congress of Geologists is to be held at Zurich in August, 1894. A preliminary circular, signed by professors Renevier, Heim and Golliez, has already been issued, together with a brief Proces-verbal of the meeting held on the 3d of August, 1891, at Salzburg, which was concerned with certain European maps. Considering the nature of their country the Swiss geologists are arranging two kinds of excursions, some across the Jura and the Alps for "those accustomed to long walks" and others for the less sturdy, during which steamboats, railways and other conveniences will be utilized. Full particulars will be furnished later. The meetings will be held at Zurich, but the excursionists will reassemble at Lugano for the final meeting of the session.

The Annual Report of the Lausanne Natural History Museum, of which Prof. Renevier is keeper, shows the important accession of a large collection of Triassic fossils made by the professor himself at Hallstadt. Prof. Renevier, as may be seen above, is one of the committee on the next International Congress of Geologists.

The professorship of Geology and Mineralogy, at Breslau, left vacant by the death of the late professor F. A. Roemer, will be divided. The Professor Ordinarius will occupy the chair of Petrology and the Professor Extraordinarius will have charge of the department of paleontology. It is considered probable that Dr. Fritz Frech of Halle, one of the leaders of the younger school of German geologists, will receive the latter. Dr. Frech is well known as the monographer of the Triassic Corals and as a writer on past zoölogical distribution.

Mr. F. A. Bather contributes a paper to the last report of the "Museums Association" on the fossil crinoids in the British Museum, in which he describes his attempt to put into practice modern ideas of museum arrangement. He accepts as his rule the American maxim that a museum is a collection of labels illustrated by specimens. The paper consists mainly of a reprint of the thoughtfully prepared labels which he has attached to his collection and will serve as an admirable model for educational museums.

A SPECIAL ROOM 80 FEET BY 40, to be termed the "Barrandeum" has been appropriated in the New Royal Bohemian Museum for the exhibition of the collection of fossils made by the late Dr. J. Barrande, illustrating his "Système Silurien de la Bohême;" and we learn that the "Barrande Fund" founded by Dr. Anton Fritsch for the further encouragement of the work that ceased at Barrande's death, has now reached the sum of 10,000 florins. The interest on this fund, which has been raised by voluntary contributions, will be available next year for the endowment of research in the Silurian formation in Bohemia, and it is hoped that some paleontologist will be thereby induced to study the smaller organisms of the system.

THE TEXAS STATE GEOLOGICAL SURVEY HAS RECENTLY ADDED to its working force, as chemist, Dr. W. H. Melville, who has been for ten years connected with the United States geological survey; and, in the department of paleontology, Mr. G. D. Harris, late assistant in Tertiary invertebrate paleontology on the same survey. Prof. Cragin's engagement with the Texas survey has recently been extended to February, 1893, his work including chiefly vertebrate and Cretaceous invertebrate paleontology.

DR. GEORGE A. KŒNIG, of the University of Pennsylvania, has been appointed professor of chemistry at the Michigan Mining school, Houghton.

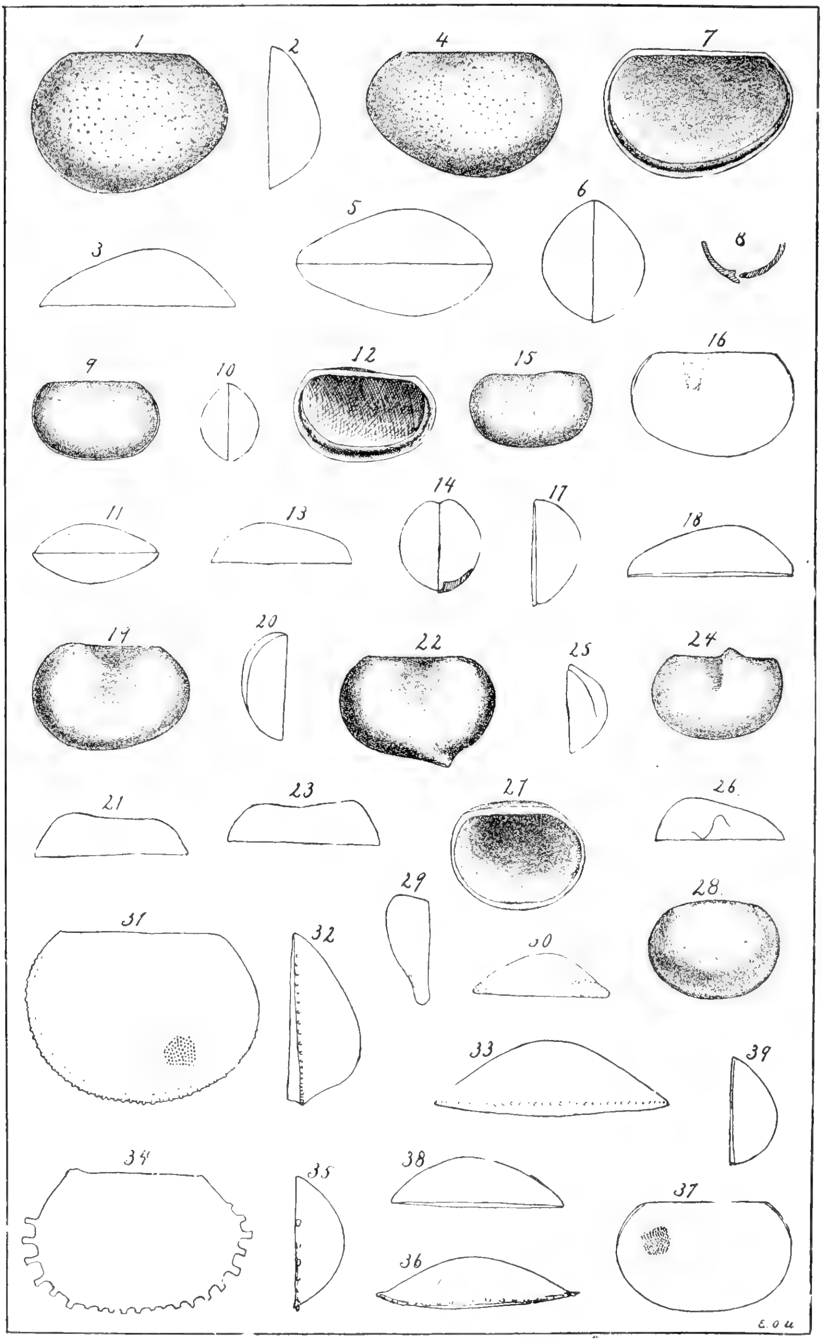
THE NEXT ANNUAL MEETING of the A. A. A. S. will be held in August, 1893, at Madison, Wis. Prof. William Harkness, of Washington, D. C., was elected president; Prof. F. W. Putnam, of Cambridge, Mass., permanent secretary; T. H. Norton, of Cincinnati, general secretary, and H. L. Fairchild, of Rochester, secretary of the council. It was announced that an anthropological congress would be held at the Columbian Exposition during the week following the next annual meeting of the A. A. A. S., with representatives of every American tribe, from Terra del Fuego to the Esquimaux of the Arctic zone. As an outgrowth of this congress, it is meant to found a museum of ethnology at Chicago, materials for which are now being collected by the ship load in Yucatan, Ecuador, Peru, Chile and elsewhere. A committee was appointed to secure rooms for the various sections of the A. A. A. S. to be used as headquarters during the entire period of the exposition, each room to be in the building the contents of which are most closely allied to the branch of science represented.

CHARLES S. PROSSER, LATE OF THE NATIONAL MUSEUM, Washington, has been elected to the professorship of natural history in Washburn College, Topeka, Kas., left vacant by Prof. Cragin. The work of the chair will be developed principally along the line of geology, and will embrace an examination of the stratigraphy and paleontology of the Upper Carboniferous about Topeka, extending finally over a considerable part of eastern Kansas.

THE PEERLESS COAL COMPANY, OF DALLAS, TEXAS, has purchased the Calvert Bluff lignite, or brown coal, deposits, near Calvert, Texas, and will begin the briquetting of brown coal immediately. This is one of the direct and practical results from the investigation, by state geologist Dumble, of European methods of the utilization of brown coal, and from his attempts to initiate such utilization of brown coals in America. The term "lignite," as generally used in this country, is erroneously applied, most of the varieties of coal so called being either brown coals, pitch coals, or glance coals; the term *lignite* being properly applicable to the charcoal-like varieties which retain more or less perfectly the woody structure.

THE AGE OF THE EOZOON. "It is well to note here that if the Eozoon is really animal in origin, the 'Laurentian' rocks of Canada, in which it occurs, must be Huronian, or the later of Archæan terranes." J. D. DANA, *Amer. Jour. Sci., June, 1892, p. 462.*

ANOTHER OLD OUTLET OF LAKE HURON. In *The Nation* for September 22, Prof. G. F. Wright describes an old channel which connects lake Nipissing with Trout lake. The former is tributary to lake Huron, about 70 feet lower, by way of French river, and the latter flows by way of the Mattawan river into the Ottawa river. A subsidence amounting to only a trifle more than a hundred feet, would turn the current from lake Huron through lake Nipissing into the Mattawan and thence into the Ottawa, thus robbing Niagara of most of its glory. The subsidence which came with the close of the Glacial epoch was more than ample to produce this change, and the great lakes seem to have had discharge there for thousands of years before they acquired that by way of Niagara. This discovery confirms, in the opinion of Prof. Wright, the surmise of Mr. G. K. Gilbert, who reasoning from a known differential northerly subsidence had suggested some time ago that the great lakes may formerly have had a discharge by way of the Ottawa river. The duration of this discharge must be added to the usually accepted length of post-glacial time, so far as it is based on a computation of the recession of Niagara falls, since the Niagara recession must have begun after this channel was closed.



NEW LOWER SILURIAN OSTRACODA.

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NEW LOWER SILURIAN OSTRACODA, NO. 1.

By E. O. ULRICH, Newport, Ky.

PLATE IX.

This is the first of a series of papers upon these fossils that I hope to issue in the near future. Each part will be accompanied by at least one plate, and the rate of publication will depend very largely upon the leisure time at my disposal.

My aim is to advance the subject to a point where it will be possible to treat it monographically. The first essential for that condition is, obviously, a knowledge as complete as possible of the forms to be worked upon and classified. I propose, therefore, to publish descriptions and figures of all the new forms now in my hands, with occasional notes upon previously known species. I may add that these papers are to be regarded as in a great measure preliminary. Many of the species, all of those occurring in the Nortwestern states, will be reworked, I trust, more fully, and republished in Vol. III of the final reports of the Geological and Natural History Survey of Minnesota.

The systematic classification of these, mostly minute, paleozoic fossils, is attended with unusual difficulties. This fact must become apparent to anyone taking the trouble to enter into critical comparisons between the British, German and American works on the subject. It is not that a particular style of treatment pertains to each of these nations. No, no. It is, rather, that the number of styles is limited only by the number of authors. The greatest trouble seems always to have been experienced in drawing the lines between the various genera constituting the large family *Leperditiidæ*, some authors claiming the existence of a complete chain of links connecting the simplest *Primitia*-aye, even *Leperditia*—with the most complex types of *Beyrichia* and *Strepula*. Now, while this is probably true, it seems to me that but too often these chains contain closely approximated links that in reality illustrate mere resemblances rather than genetic relationship.

It is the determination of the genealogical affinities that is the prime necessity in building up a permanent classification. With nothing but the shells to guide us, can we hope to reach satisfactory conclusions respecting the paleozoic, especially the lower paleozoic, Ostracoda? We can try.

In the accompanying plate several forms are illustrated of which it is really difficult to decide whether they should be called species or varieties. One thing, however, seems to be certain, and that is that, within reasonable limitations, each form is constant and, therefore, distinguishable from the others. That they represent recognizable stages in the developmental history of the *Leperditiidæ* is all that I claim, it being quite immaterial to me what rank in classification the proposed names may ultimately hold.

Leperditia tumida, n. sp.

PLATE IX, FIGS. 1 to 3.

Length of a large right valve, 2.6 mm.; hight, 1.82 mm.; thickness, 0.75 mm.

Valves ovate, rather short, the posterior end much the widest, tumid, the convexity of the surface, except for a slight flattening and lengthening of the dorsal and anterior slopes, nearly uniform. Surface obscurely punctate, otherwise smooth, there being no external signs of either the eye-tubercle or muscle spot.

This species compares with *L. nana* Jones, about as closely as with any other Lower Silurian form described, but being without an eye-tubercle and of more rounded shape, it is readily distinguished. The Carboniferous species *L. okeni* Münster, *L. carbonaria* Hall, and others of that type, agree very closely in nearly every respect. All these species differ from typical *Leperditia* in the method of closing the valves, the latter having them merely to overlap, while in the species under consideration the ventral edge of the right valve fits into a groove in the edge of the left. (See Figs. 7 and 12 of plate IX.)

Formation and locality: This species is very abundant (associated with Bryozoa) in the shaly part of the Birdseye limestone at High Bridge, Kentucky. These layers are here nearly on a level with the bridge. The species also occurs at Frankfort, in the same beds.

Leperditia mundula, n. sp.

PLATE IX, FIGS. 4 to 8.

Length of en ire carapace, 2.6 mm.; hight, 1.64 mm.; thickness, 1.4 mm.

This species differs from *L. tumida* in being less high, causing the outline to be more elongate. In an end view the convexity of the valves is also more uniform. A very faintly defined ovate area is distinguishable, by depression of the surrounding surface, just a trifle in front of the center of the dorsal slope.

Formation and locality: This form occurred in considerable number in a small package of soft shale obtained from the Birdseye (? Chazy). limestone, near the bottom of the Kentucky river gorge at High Bridge, Ky. This bed, which furnished also *L. æquilatera* and *L. germana*, is at least two hundred and sixty feet beneath the *L. tumida* horizon.

Leperditia æquilatera, n. sp.

PLATE IX, FIGS. 9 to 11.

Length of entire carapace, 1.7 mm.; hight, 1.03 mm.; thickness, 0.8 mm.

Carapace rather elongate, with the ends rounded, sub-equal, the back straight, the ventral edge gently convex and nearly parallel with the dorsal. Surface of valves smooth, almost uniformly convex, there being only a very slight and quite undefined mesial depression in the dorsal slope.

Distinguished from *L. mundula* in having the ends of nearly equal size and curvature, and the outline in a ventral view more uniformly convex, so that the point of greatest thickness is very near the middle of the valves.

Formation and locality: Same as the last. About forty specimens.

Leperditia inflata, n. sp.

PLATE IX, FIGS, 12 to 15.

Length of average left valve, 1.9 mm.; hight, 1.22 mm.; thickness, 0.54 mm.

Valves ventricose, the outline usually very much as in *L. æquilatera*, only the posterior end is somewhat wider and inflated, so that this half of the dorsal region projects more or less beyond or above the hinge line. The postero-dorsal angle, also, is more pronounced. Groove in ventral edge of left valve sharply defined. Surface with a broad, undefined mesial depression in the dorsal slope. This depression is as much stronger than the one in *L. æquilatera* as it is weaker than the one in *L. sulcata.*

Formation and locality: Same as the last One hundred specimens, or more.

Leperditia germana, n. sp.

PLATE IX, FIGS. 16 to 18.

Length of average left valve, 2.17 mm.; hight, 1.4 mm.; greatest thickness, 0.67 mm.

This form is very closely related to *L. mundula*—perhaps it is merely a local variety of that species. It differs in having the ends more equal, the surface more convex in the dorsal half, and in having a very narrow rim or marginal channel, visible in a side view only, at the ends. Again, instead of a slight elevation surrounded by correspondingly gentle depressions, we have in *L. germana* only a sulcus. This is about as strong as the one in *L. inflata*, which species the present form resembles rather closely also in the outline. The basal line, however, is usually more convex and with the most prominent point nearer the center. But the most important difference lies in the lesser inflation of the posterior half of the dorsal region. (Compare Figs. 14 and 17, Pl. IX.)

Formation and locality: Associated with *Schmidtella crassimarginata* Ulrich, at Mineral Point, Wisconsin, where it occurs abundantly in some of the thin layers of the Birdseye or "Lower Blue" limestone.

Leperditia sulcata, n. sp., and var. ventricornis, n. var.

PLATE IX, FIGS. 19 to 23.

Length of an average right valve, 2.1 mm.; hight, 1.38 mm.; thickness, in anterior half, 0.48 mm., in posterior half, 0.58 mm.

Valves sub-ovate, ends nearly equal, the posterior a little the widest; back straight for about three-fifths of the entire length; ventral edge gently convex, the most prominent part a little behind the center. Surface rising abruptly from all the edges except the dorsal which is occupied by the expanded terminus of a broad sulcus which, though shallow and of undefined limits, is, nevertheless, always a conspicuous feature of the valves. In a ventral view the profile is highest a short distance within the ends, while the central portion is at least straight and in most cases decidedly concave. Closure of valves as in *L. inflata.*

This form may be regarded by some authors as nearer *Primitia* than *Leperditia*, but I have satisfied myself fully that it, like the following species (*L. dorsicornis*), is an extreme development of the type begun in the stock that produced the *L. æquilatera*, *inflata*, and *germana* of this paper. From these species it is sufficiently distinguished by the more abrupt end and ventral slopes, and the greater development of the sulcus.

Of the form that I propose, provisionally, to name as var. *ventricornis* I have seen only the right valve illustrated. So far as I can see, the only difference between it and the typical form of the species is found in the obtuse and retrorsely directed ventral prominence.

Formation and locality: Associated with, but less abundant than, *L. tumida*, in the Bird-eye limestone at High Bridge, Ky.

Leperditia (? Primitia) dorsicornis, n. sp.

PLATE IX, FIGS. 24 to 26.

Length of a right valve, 1.72 mm.; hight, 1.1 mm.; greatest thickness (center of posterior half) 0.54 mm

Valves subelliptical, slightly oblique, the ends subequal, the back straight nearly to the posterior extremity; the latter is gently convex and almost vertical in the upper two-thirds, while in the lower third the outline merges rapidly into the uniformly convex basal margin; anterior end uniformly curved. Surface much the highest in the posterior half, with a part prolonged dorsally into a short and obtusely pointed prominence that bends down close to the hinge line and projects somewhat beyond it. This prominence gives definition to the posterior side of a distinct sulcus, extending almost half across the valve from the central part of the dorsal edge, and forward along the latter.

This species ought, perhaps, to be called a *Primitia* but for the reason given under *L. sulcata* I have chosen to designate it as above. Of the species believed to belong to the same line of development, *L. inflata* seems to be the nearest. They are, however, readily distinguished by the concentration of the dorsal prominence and the greater definition of the sulcus in *L. dorsicornis*.

Formation and locality: The only specimen seen was found in the Hudson River rocks at Savannah, Illinois.

Leperditia granilabiata, n. sp.

PLATE IX, FIGS. 31 to 33.

Length, of right valve, 2.1 mm.; hight 1.52 mm.; greatest thickness 0.6 mm.

Valves broadly subelliptical, scarcely oblique, the ends strongly rounded, nearly equal, the ventral margin uniformly and more than usually convex. Free edges, except in the cardinal regions, set with small but prominent papillæ. Surface minutely punctate, ventricose in the lower half, flattened in the upper; with point of greatest convexity much beneath the middle. A faint smooth (non-punctate) spot occurs just in front and above the center.

This species might with others described in this paper be placed with *Aparchites*, Jones, but there is something so peculiar about Prof. Jones' type of the genus and one or two undoubtedly congeneric species, that I hesitate to enlarge the limits of the genus beyond them.

Formation and locality: Rare in the upper part of the Trenton shales (Phylloporina beds) at St. Paul, Minn.

Leperditia millepunctata, n. sp.

Plate ix. Figs. 37 to 39.

Length, of a right valve, 1.57 mm.; hight 1.0 mm.; greatest thickness 0.45 mm.

This species is very similar to *L. æquilatera* of this paper, but I have no doubt of their specific distinctness. There is a slight channel and rim about the free edges wanting in that species, while the surface also is very finely punctate, and more uniformly convex, the profiles of the two forms being different. The present species again is a little higher.

It is possible that this species should be placed with *Isochilina* rather than *Leperditia*, but as near as can be determined from the material at hand it appears that the valves overlap slightly, the left over the right, along the ventral border.

Formation and locality: Trenton shales, one mile east of Fountain, Minnesota. Rare.

Leperditia fimbriata, n. sp.

Plate ix. Figs. 34 to 36.

Length, of a right valve, (excluding spines) 1.88 mm.; hight 1.23 mm.; thickness 0.44 mm. Length of dorsal edge 1.2 mm.

Valves suboval, moderately and almost uniformly convex, the ends nearly equally rounded, the posterior a little the wider. Extremities of dorsal edge angular, the posterior somewhat prominent. Point of greatest convexity slightly below the center. The entire ventral border and the ends, excepting the upper third on each side, with a fringe consisting of long, almost paliform, processes. At the ends the intervals between these processes is about 0.1 mm., but in the central part of the ventral edge they are shorter, and the projections themselves probably not so long.

The peculiar fringe distinguishes this species from all the others now referred to *Leperditia*.

Formation and locality: Only one valve of this species is known. It was collected by the author in the upper beds of the Cincinnati or Hudson River group, near Spring Valley, Minnesota.

Schmidtella, n. gen.

Carapace small, rounded, moderately convex. Valves inflated in the dorsal region so that this part projects shoulder-like over and out from the nearly straight hinge line. Right valve slightly the larger, its ventral edge overlapping that of the left. No sulcus nor tubercles.

Type: *Schmidtella crassimarginata*, n. sp.

I am somewhat in doubt respecting the systematic position of this genus, but provisionally would place it near *Aparchites*, Jones, among the *Leperditiidæ*. Nor am I satisfied that the description should not be modified so as to include several smaller, as yet undescribed, species which agree in all other respects except in having an obscure subcentral impression.

The name is given in recognition of the valuable services rendered to Silurian paleontology by Dr. F. Schmidt, of St. Petersburg, Russia.

Schmidtella crassimarginata, n. sp.

Plate IX, Figs. 27 to 30.

Length, of an average right valve, 1.25 mm.; hight 1.0 mm.; greatest thickness 0.4 mm.

Valves broad-oval, very slightly oblique, the ends almost equal, the lower half with the ventral margin curved to form somewhat less than a semicircle. Dorsal region flattened, slightly convex in a side view, rising very abruptly from and projecting slightly over the nearly straight hinge line. Point of greatest convexity above the center. An undefined but rather conspicuous broad furrow around the ends and ventral margin, least distinct posteriorly, produces the thick border that has suggested the specific name.

The obscurely defined, heavy and wide margin, and the flat dorsum are peculiarities that will distinguish this species at once from all described Silurian Ostracoda.

Formation and locality: Very abundant on thin slabs of "Lower Blue" or Birdseye limestone collected at Mineral Point, Wisconsin.

EXPLANATION OF PLATE IX.

Figs. 1 to 3, LEPERDITIA TUMIDA, n. sp. p. 264.

1. Right valve, of the usual form, × 10; 2, posterior, and 3, dorsal view of same, in outline.

Figs. 4 to 8, LEPERDITIA MUNDULA, n. sp. p. 265.

4. Left side of entire carapace, × 10; 5, ventral, 6, anterior view of same in outline.
7. Interior of a left valve, × 10, showing groove into which the ventral edge of the right valve is inserted when the valves are closed.
8. Diagrammatic sectional view of the ventral portion of the carapace.

Figs. 9 to 11, LEPERDITIA ÆQUILATERA, n. sp. p. 265.

9. Right side, 10, anterior, and 11, ventral view of an entire carapace, × 10.

Figs 12 to 15, LEPERDITIA INFLATA, n. sp. p. 265.

12. Interior of full grown left valve; 13, dorsal view of same, × 10.
14. Outline anterior view of closed carapace.
15. A smaller left valve, approaching *L. æquilatera* in outline, × 10

Figs. 16 to 18, LEPERDITIA GERMANA, n. sp. p. 266.

16, 17 and 18. Three outline views, side, anterior and ventral, of a left valve of this species from Mineral Point, Wis., × 10.

Figs. 19 to 21, LEPERDITIA SULCATA, n. sp. p. 266.

19, 20 and 21. A right valve, × 10, with outline anterior and ventral views of same.

Figs. 22 and 23, LEPERDITIA SULCATA, var. VENTRICORNIS, n. var p. 266.

22. A left valve, × 10; 23, outline of same in a ventral view.

Figs. 24 to 26, LEPERDITIA (? PRIMITIA) DORSICORNIS, n. sp. p. 267.

24. A left valve, × 10; 25 and 26, outlines of same in anterior and ventral views.

Figs. 27 to 30, SCHMIDTELLA CRASSIMARGINATA, n. gen. et sp. p. 269.

27. Interior of right valve, × 10; 28, exterior of another right valve, equally magnified; 29 and 30, anterior and ventral views.

Figs. 31 to 33, LEPERDITIA GRANILABIATA, n. sp. p. 267.

31, 32 and 33. Three outline views, side, posterior and ventral, of a right valve, × 15. The punctæ of a small part of the surface are shown in 31.

Figs. 34 to 36, LEPERDITIA FIMBRIATA, n. sp. p. 268.

Three outline views of a right valve, × 15.

Figs. 37 to 39, LEPERDITIA MILLEPUNCTATA, n. sp. p. 268.

Three outline views, and a small portion of the punctate surface, of a right valve, × 15.

TWO NEW LOWER SILURIAN SPECIES OF LICHAS (SUBGENUS HOPLOLICHAS).

By E. O. Ulrich, Newport, Ky.

Lichas (Hoplolichas) robbinsi, n. sp.

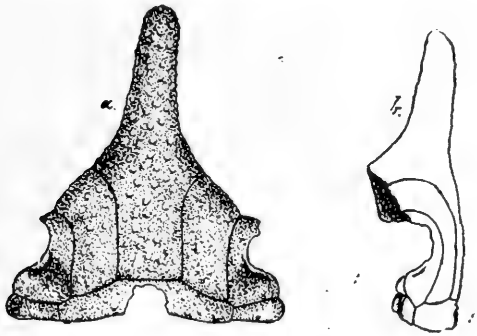

Fig. 1. *a*, imperfect glabella of the natural size; *b*. profile of same. Specimen wanting the free cheeks and defective at the inner edge and at the center of the occipital ring.

Glabella, including frontal prolongation, with the length equalling one and one-half times the greatest width. Without the frontal process the width is greater than the length. Frontal lobe very gently convex and with parallel margins in the posterior half, then expanding, the anterior half grows tumid and finally is produced forward into a single strong baculate process. Lateral lobes undivided, with margins almost parallel, the width and length about as one is to two and one-half, very little convex except in front where they bend outward and downward to the frontal margin. Furrows between the central and lateral lobes very narrow; likewise the occipital furrow. Occipital ring rather narrow at the ends, nearly twice as wide in the middle where it probably supported one or two central spines. Facial sutures apparently normal. Fixed cheeks of the form shown in the drawings, slightly depressed and with a linear curved impression immediately behind the eyes. Surface covered with papillæ just visible to the naked eye. At intervals of one or two mm. there is a larger one. Free cheeks, eyes and thorax not observed.

Since these two species, excepting the doubtful *L. hylæus* Hall, are the first to be described from American rocks having the characters of the subgenus *Hoplolichas*, Dames, they are not likely to be confounded with any of our known species of *Lichas*. None of the European forms known to me are very closely related.

The specific name is given in honor of Dr. C. H. Robbins, of Wykoff, Minnesota, an indefatigable collector and student of the fossils of the Lower Silurian localities in southern Minnesota. The Galena limestones especially, have been made to furnish an abundance of their rich stores of interesting forms through his endeavors.

Formation and locality: In the middle beds of the Galena (Trenton) limestone near Wykoff, Minnesota.

Lichas (Hoplolichas) bicornis, n. sp.

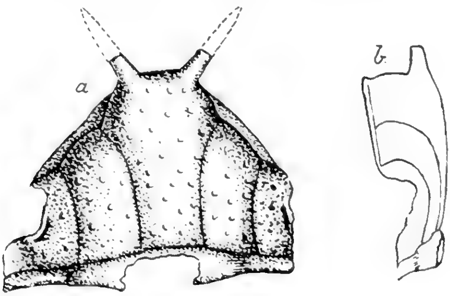

Fig. 2. *a*, imperfect cephalic shield, natural size; *b*, profile of same.

In this species the form of the lobes of the glabella (excluding the frontal prolongations), the fixed cheeks and the occipital ring are so much like these parts of the preceding species that it is not necessary to describe them. I shall therefore merely point out the most striking differences between the two species.

In the first place the anterior part of the central lobe of the glabella is not drawn out into a single baculate prolongation, but supports two much smaller diverging horn-like processes, each 1.5 mm. in diameter and probably less than 10 mm. in length. The dorsal surfaces of the three longitudinal lobes of the glabella are more convex transversely, and the lateral ones a little more elongate (the length is scarcely greater than twice the width). Finally there is a slight difference in the papillose marking of the test, the large set of papillæ being more prominent in *L. bicornis*.

The two frontal horn-like processes will distinguish this species at once from all known American species of *Lichas*.

Formation and locality: Upper beds of the Cincinnati group near Spring Valley, Minnesota.

THE PLATYCERAS GROUP OF PALEOZOIC GASTEROPODS.

By Charles Rollin Keyes, Des Moines.

It has been shown recently* that there are no good grounds for separating, generically, the recent forms of Capulus from the more typical Platycerata. Even if it were desirable to distinguish between the modern and ancient sections, Conrad's familiar title could not stand. For, aside from being synonymous with Montfort's genus, Platyceras had been preoccupied as a generic term for more than three-quarters of a century. The name was used by Geoffrey† as early as 1746, for a genus of Coleoptera; and again by Latreille‡ in 1796. Nor can Œhlert's§ recent revival of Phillip's Acroculia be sustained, since the typical species are also true Capuli.

Besides the two genera already mentioned, the shells of this group have been variously assigned to Pileopsis of Lamarck,¶ Actita of Fisher von Waldheim,**Acroculia of Phillips,†† Orthonychia of Hall,‡‡ and some others. The relative merits of these names, as generic titles, have been fully discussed elsewhere.§§

There has long been considerable difficulty in attempting to separate certain members of the group in question, on the one hand from some forms of Platystoma, especially from those species in which there is a greater or less tendency for the shells to uncoil; and, on the other hand, from various genera of patelloid shells. As might be expected in a group of gasteropods presenting so few constant characters, which can be satisfactorily relied upon as classificatory criteria, it is often almost impossible to clearly distinguish between certain of these species. Many structural features heretofore considered important in identification have been shown, recently, to possess very little, if any, specific value, owing to their great variability. It therefore becomes necessary to regard as of the utmost significance the basing of species

*American Geologist, Vol. vi, p. 6.

†Hist. abrégée des Insectes, (1764).

‡Précis des charactères des Insectes, (1796).

§Bul. Soc. Géol., France, (3), t. xi, p. 602.

¶Anim. sans Vertebr., t. vi, p. 16. (1822.)

**Mem. Soc. imp. Nat. Moscau, t. vi, p. 234. (1823.)

††Pal. Foss. Cornwall, p. 93. (1840.)

‡‡Rep. 4th Dist, New York, p. 172. (1843.)

§§Proc. Acad. Nat. Sci., Phila., p. 150-181. (1890.)

upon general resemblances rather than upon unimportant, varient characters arising from diverse conditions of environment imposed by a more or less extensive geographic distribution. Thus, in choosing for classification purposes the characters of any group, it is evident that only those features exhibiting the least tendency to modification are available. Even the most constant structures appear to lose much of their stability at some period during the existence of the group--whether specific, generic or family; while other characters, more or less varient in the early stages of development, later become less liable to change. At some time or other these features blend and thus arise the transitional forms.

It may be assumed then, that in many groups of the same genetic origin some varieties will present features that have remained for a long time practically unmodified; while others exhibit the same characters in a highly specialized, but ever changing, condition. And it is of great interest to note in this connection that the latter—those having greatly exaggerated features—are the forms whose existence is of comparatively short duration; and that with these intensified structures the development is rather rapid, while their culmination is soon followed by a great diminution of the group's vitality, or more commonly its extinction.

Under Conrad's generic name upwards of three hundred species of gasteropods have been proposed. In such a group of shells having so few salient characters for classification and a great range of variation, it is not hard to foresee some of the difficulties to be encountered in attempting to arrange satisfactorily the many different forms. The placing of Platyceras, Orthonychia, etc., as sub-genera under Capulus, as has been done by Zittel* and others, manifestly does not meet the requirements, especially as regards the American members. Moreover, the group has been made to embrace a great variety of species, some of which are clearly not at all closely related genetically. Of these a few forms have been referred lately to the places to which they more properly belong. But there are still a considerable number of these shells which are evidently not members of the group, yet whose generic affinities cannot be determined at present, with exactness.

In the recently issued synopsis† of the Calyptræidæ occurring

*Handb. der Pal., II Band, p. 216.

†Proc. Acad. Nat. Sci., Phila., pp. 150-181. (1890.)

in the upper Paleozoic of America, the co-extension of Platyceras and Capulus was fully recognized and all the Carboniferous species hitherto referred to the former genus placed under the latter. At the same time considerable doubt was expressed as to the advisability of associating all the forms mentioned under a single generic title. When it comes to extending the examination to all the species usually embraced in Conrad's group, a very heterogeneous assemblage of shells is encountered. Hall, Meek and others have repeatedly called attention to the difficulties in the arrangement of the Platycerata. The first named author has even proposed two generic terms to include some of the more aberrant forms.

In reviewing all the described species of the group under consideration, three more or less well defined and generally easily recognizable sections may be made out. The three are distinguished readily from one another by their general shape; but there are other features equally distinctive. One section is characterized by having a small, closely coiled spire, more or less contiguous with a large campanulate body whorl. Another group includes those shells having very small apices, usually arched but seldom closely coiled, the last volution very much elongated vertically, and often spiral. The third assemblage embraces the straight conical forms with little or no convolution of apical parts. To the first of the three groups, Monfort's generic title, Capulus, applies; for the second and third it seems proper to revive Hall's names, Orthonychia and Igoceras. In a few cases these groups along certain lines seem to merge somewhat and their present limits eventually may require some modifications. On the whole, however, they appear to satisfy the requirements much better than any of the commonly accepted arrangements previously used.

The American Platycerata now assigned to each of the three groups may be enumerated as follows:

CAPULUS.

argo Hall.	*auriculatus* Hall.
billingsi Hall.	*biserialis* Hall.
bisinuatus Hall.	*bucculentus* Hall.
calantica Hall.	*carinatus* Hall.
clavatus Hall.	*crassus* Hall.
cymbium Hall.	*dilatatus* Hall.
dumosus Conrad.	*echinatus* Hall.
equilateralis Hall.	*erectus* Hall.

fornicatus Hall.
gibbosus Hall.
intermedius Hall.
lodiensis Meek.
multisinuatus Hall.
newberryi Hall.
nodosus Conrad.
occidens Walcott.
paralius White and W.
pentalobus Hall.
platystomus Hall.
reflexus Hall.
rictus Hall.
spinigerus Worthen.
subsinuosus Worthen.
sulcoplicatus Hall.
thetis Hall.
undatus Hall.
ventricosus Conrad.
gebhardi Conrad.
haliotoides M. & W.
latus Keyes.
magnificus Hall.
multispinosus Meek.
niagarensis, Hall.
obliquus Keyes.
ovalis Stevens.
parvus Swallow.
perplicatus Hall.
plicatilis Hall.
retrorsus Hall.
sinuatus Hall.
subrectus Hall.
sulcatus Conrad.
symmetricus Hall.
tribulosus White.
undulostriatus Hall.

IGOCERAS.

conicum Hall.
fissurellum Hall.
perplexum Hall.
pyramidatum Hall.
subplicatum Meek & W.
capulus Hall.
pabulocrinus Owen.
plicatum Conrad.
quincyense McChesney.

ORTHONYCHIA.

acutirostre Hall.
arcuatum Hall.
chesterense Meek and W.
cornuforme Winchell.
cyrtolites McChesney.
formosum Keyes.
lamellosum Hall.
subrectum Hall.
tubiforme Hall.
agreste Hall.
attenuatum Hall.
concavum Hall.
curvirostrum Hall.
dentalium Hall.
incile Hall.
spirale Hall.
tortuosum Hall.
unguiforme Hall.

Some of the forms included in the above are undoubtedly synonymous, but they cannot be eliminated until more satisfactory material has been examined. By transferring certain apparently anomalous species to other genera, the arrangement of the entire group seems to be much more in accordance with the observed affinities and differences of the various species than any other yet suggested. And in a treatment, soon to be issued, of the leading forms occurring in the Mississippi basin the plan here proposed has been followed.

The great range of variation, even in a single species, together with some of the causes tending to produce these rapid changes. has been fully discussed in another place. making it unnecessary to take up again the habits of these organisms, detected even in the fossils by the intimate association of the gasteropods with crinoids. Concerning this phase of the question much might be said. The conclusions reached may be briefly summed up as follows:

(1.) The gasteropod shell invariably lies over the anal opening of the crinoid.

(2.) The mollusk remained in this position for a considerable period, probably for the greater part of life, as is shown by the shells on highly ornamented calyces and after the removal of them by the concentric grooves made on the ventral plates.

(3.) The growing shell followed closely the inequalities of the surface upon which it rested—depressions giving rise to furrows and protuberances to folds or nodes.

(4.) Shells lying simply on flat surfaces are much more depressed and proportionally broader than those clinging to the vertical or inclined portions of calyces in which the anal opening is situated laterally.

The third of these statements is perhaps best illustrated by crinoids having low interradial areas and elevated radial regions, and is the probable explanation of the frequent occurrence of the more or less distinctly five-lobed calyptræan shells. Until very lately this phenomenon has admitted of no direct causal interpretation.

Since the appearance of the recent papers on the habits of the ancient calyptræans it has been inferred that these gasteropods were parasitic in their manner of living. This was not the case. For in no instance did the mollusks probably interfere at all with the nourishment of the crinoids, but merely fed, in part at least, upon refuse matter.

CLASSIFICATION OF THE THEORIES OF THE ORIGIN OF IRON ORES.

By H. V. Winchell, Minneapolis.

A. Mechanical.

a. Extra-terrestrial or cosmical.

1. Meteoric fall. [1.]*

b. Terrestrial.

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* Figures in brackets refer to the theories as numbered and discussed in "The Iron Ores of Minnesota," Bulletin No. 6, Minn. Geol. Sur.

1. Subterranean—eruption in dykes or accompanying basaltic flows. [2.]
2. Superficial action.
   a. Violent abrasion and transport. [13.]
   b. Ordinary erosion.
      1. Concentration of iron sands. [14.]
      2. Oceanic sedimentation. [8.]

B. CHEMICAL.

a. Changes in situ.
1. Change in the kind or quantity of iron already present in the rocks.
   a. Alteration of diffused ferric oxide into ferrous carbonate. [10.]
   b. Metamorphism of bog ore. [11.]
   c. Metamorphism of lake ore. [12.]
   d. Alteration of ferrous carbonate or sulphide into ferric oxide. [8 in part.]
2. Change in the kind or quantity of other minerals.
   a. Substitution of iron oxide for some non-ferriferous mineral. [17.]
   b. Concentration, by removal of the other constituents. [4.] Similar to B a 1.
   c. Electro-telluric action. [16.]

b. Removal by chemical action and subsequent deposition.
1. By action of heat—sublimation. [3.]
2. By action of water.
   a. In drainage basins.
      1. Oceanic precipitation. [8 in p't.]
      2.
         a. Secondary product of the decomposition of basic rocks. [18.]
         b. Secondary product from the decomposition of pyrite. [7.]
   b. In the rocks.
      1. Saturation of porous strata. [5.]
      2. Infiltration into cavities. [6, 15.]
   c. Deposit by springs. [9.]

Mr. W. J. McGee, in "The Pleistocene History of Northeastern Iowa," revives the use of the term *geest*, applied by DeLuc in 1816, and afterward by Eaton and Beck, in America, to "the immediate products of rock decay in situ." P. 279, *Eleventh Annual Report of the Director U. S. Geol. Survey.*

ON THE FORMATION OF OÖLITE.*

By Dr. A. Rothpletz, of Munich.

On the low shore of the Great Salt lake in Utah, there lie between the pebbles and sand-grains, in great multitudes, snow-white calcareous corpuscles. They are thrown on the smooth strand by the waves of the lake and form a substantial part of the beach-sand. Where they still lie in the water, we usually see them partly covered with a bluish-green alga-mass.

I could take with me last fall only dry material of this alga; but that sufficed perfectly to recognize that the algoid bodies consisted of colonies of *Glœocapsa* and *Glœothece* cells, which richly secrete carbonate of lime.

The cells of the *Glœocapsa* are 2 μ in diameter and spherical, those of *Glœothece* 2—3 μ thick and 4—5 μ long.

They are invested with a clear, transparent, jelly-like membrane, which exceeds the cells in thickness. There are often several cells in one membrane, and the more or less spherical membranes are always pressed closely together, creating nearly the appearance of a uniform mass of jelly.

The lime is enclosed in the alga-body in the form of rounded tubercles which often mass themselves together into larger, irregular tubercular bodies. It is a fine-grained aggregate of calcite which always incloses numerous dead alga-cells that have already lost their greenish coloring.

The snow-white and partly silver-gray calcareous bodies of the strand are of three-fold form: first, there are irregular tubercular bodies attaining several millimeters in diameter, second, spherical or oval forms for the most part one-third of a millimeter in diameter, and, third, long, thin rods about one-half a millimeter long and one-tenth of a millimeter broad.

If we dissolve these bodies in dilute acid, the dead and shriveled fission-algæ become free in quite the same way as by dissolving the lime of the living algæ. The snow-white, calcareous bodies may, therefore, be understood as dead alga-bodies.

The rounded to oval forms are, indeed, both by their external form and by the microscopic arrangement of the calcite, true oölites. Around an inner nucleus of irregularly granular lime, are laid concentric shells with, at the same time, radial arrange-

* From the *Botanisches Centralblatt*, Nr. 35, 1892. Translated by F. W. Cragin.

ment of the calcite crystals. But even in quite delicate sections the calcareous substance, both of the nucleus and of the shells, is interrupted by scattered, minute granules. If we dissolve the section cautiously and slowly in very dilute acid, the granules remain behind exactly in their original position, and we recognize in them the dead and crumpled *Glœocapsa* cells.

The oölites of the Great Salt lake are, therefore, indubitably the product of lime-secreting fission-algæ, and their formation is proceeding day by day. The rods and tubercles are of like constitution, save that in the latter the regular concentric structure of the lime is lacking. Furthermore, the little rods appear to be richer in alga-cells than the oölites. It must be left to the American botanists to accurately trace this process of oölite-forming in place, or at least in living material.

But even now the observations communicated suffice for finding an explanation of the origin of a few other already long known oölites.

A few years since, Joh. Walther (14 w. 16 Bd. Abh. sächs. Ges. Wissensch. 1888 und 1891) described and indicated as a recent formation, oölites from the strand of the Red sea. A principal role is ascribed to decayed animals. Last year I likewise investigated these oölites in place and found that they are a very widely distributed phenomenon along the west coast of the Sinai peninsula and usually decrease in frequency toward the interior of the land, although they still may be met with many kilometers, even day's marches, distant from the shore. But they also occur in older deposits which belong to the Quaternary period and build up the subaërially formed low coastal tracts in the further environs of Suez, whence Bauerman described them very well in 1868. They are there frequently consolidated into a hard, oölitic limestone.

These oölites are distinguished from those of the Great Salt lake chiefly in the fact that their nucleus always consists of a foreign sand-grain. The concentric shell-structure is very conspicuously less developed than the radial. Then there are always to be noticed in the shells, peculiar vermiform and, not rarely, dichotomously branching canals that are filled up with calcite, which, however, in its orientation is quite independent of that of the calcite in the concentric shells, and has a much coarser grain.

If we dissolve the lime with acid, there remain here also minute grains which cohere in thin pellicles, and have quite the aspect of the fission-algæ, as they occur in the Utah oölites.

I have made the attempt to prove the plant-nature of these surviving pellicles by treatment with sulphuric acid and iodine solution, as well as with chloriodide of zinc, and thereby gained the knowledge that no blue coloring, but, indeed, a yellowish brown coloring, took place. Thus, however, behaved the fission-algæ of the Salt lake and, to my astonishment, it was quite impossible for me to color, in this way, the cell-membranes of a *Halimeda* which I had collected in the Red sea.

It appears thus that the incapacity of cellulose to be stained blue, occurs not only in the Fungi but also in the lower Algæ.

The oölites of the Quaternary deposits and those of the drift-sand are all, without exception, porcelain-white. Among those, on the contrary, which I have collected at Suez, on the strand accessible only at ebb tide, I found a smaller number which have a silver-gray to greenish-blue color and are not easily to be distinguished from the silver-gray oölites of the Salt lake, if there were not the inner foreign sand-grain.

The explanation of the inner vermiform canals, the study of the fresh-water fission-algæ furnished me. Where these live in great abundance in damp places, springs, or pools, there lime-secreting *Chroöcocci* are accustomed to grow in a forest of thread-like fission-algæ. So also may the case be in the sea. The thread-like algæ may then become encased by the lime-crusts, their room may later be filled up with lime, and thus they continue to preserve their external form. I suppose, therefore, in the vermiform structures of the Sinai oölites certain thread-like algæ which were of course not themselves immediately concerned in the oölite-formation, but by the company in which they lived were imprisoned with it. It will be the task of future dredging investigations to bring to light the living oölite-maker from the depths of the Red sea.

Eight years ago I found in the Lias of the Vilser Alps (in the so-called "Aechsele" in the Reichenbacher valley) a gray limestone in a thickness of several meters, deposited between brachiopod-bearing white and coral-bearing limestone. The same was quite filled with little, longish corpuscles which, owing to their form, I regarded as organisms. They are rods $\frac{1}{2}$ mm. thick and up to 1 mm. long, rounded off at both ends. In section, we recognize an inner nucleus of irregular granular calcite which repeats the form of the rods only on a smaller scale; therearound is laid a shell of unusually regular zonal and radial structure, exactly after the fashion of the true oölites. A foreign inner nucleus is never present, and the rather long, as well as always uniform shape of these prodigiously abundant bodies confirmed me in the belief that they are organic forms, despite the fact that the structure of the shell afforded me no point of support for it. Now, my supposition of that time gains much in probability because the agreement with the oölite rods of the Salt lake is one quite remarkable.

But structures analogous to the irregularly granular alga-limestones of the Salt lake also seem to occur in older formations. I refer especially in this statement to the so-called "great oölite structure" of the Wettersteinkalk.

The structure of certain calcareous oölites which Wethered and most recently also Bleicher (May, 1892) have investigated seems to me to have great resemblance to that of the Sinai oölite and is, perhaps, to be explained in the same manner.

In the highest degree remarkable are the 12 μ long rodlets which Bleicher has rendered visible in the iron oölites by treatment with aqua regia. He regards them, if possible, as bacteria (Comptes Rendus Acad. Science. Paris, March, 1892). If their plant-nature be established, they might also be claimed as fission-algæ.

According to the present stage of my researches, I am inclined to believe that at least the majority of the marine calcareous oölites with regular zonal and radial structure are of plant origin: the product of microscopically small algæ of very low rank, capable of secreting lime.

8 Juli, 1892.

THE IMMEDIATE WORK IN CHEMICAL SCIENCE.*

ALBERT B. PRESCOTT, Ann Arbor.

A division of science has a work of its own to do, a work that well might be done for its own sake, and still more must be done in payment of what is due to the other divisions. Each section of our Association has its just task, and fidelity to this is an obligation to all the sections. Those engaged in any labor of science owe a debt to the world at large, and can be called to give an ac-

*Retiring address as President of the American Association for the Advancement of Science, August, 1892.

count of what they are doing, and what they have to do, that the truth may be shown on all sides.

If it be in my power to make the annual address of this meeting of any service at all to you who hear it—in your loyalty to the Association—I would bring before you some account of the work that is wanted in the science of chemistry. Of what the chemists have done in the past the arts of industry speak more plainly than the words of any address. Of what chemists may do in the future it would be quite in vain that I should venture to predict. But of the nature of the work that is waiting in the chemical world at the present time I desire to say what I can, and I desire to speak in the interests of science in general. The interests of science, I am well assured, cannot be held indifferent to the interests of the public at large.

It is not a small task to find out how the matter of the universe is made. The task is hard, not because of the great quantity in which matter exists, nor by reason of the multiplicity of the kinds and compounds of matter, but rather from the obscurity under which the actual composition of matter is hidden from man. The physicists reach a conclusion that matter is an array of molecules, little things, not so large as a millionth of a millimeter in size, and the formation of these they leave to the work of the chemists. The smallest objects dealt with in science, their most distinct activities become known only by the widest exercise of inductive reason.

The realm of chemical action, the world within the molecules of matter, the abode of the chemical atoms, is indeed a new world and but little known. The speculative atoms of the ancients, mere mechanical divisions, although prefiguring the molecules of modern science yet gave no sign of the chemical atoms of this century, nor any account of what happens in a chemical change. A new field of knowledge was opened in 1774 by the discovery of oxygen, and entered upon in 1804 by the publications of Dalton, a region more remote and more difficult of access than was the unknown continent toward which Christopher Columbus set his sails three centuries earlier. The world within molecules has been open for only a hundred years. The sixteenth century was not long enough for an exploration of the continent of America, and the nineteenth has not been long enough for the undertaking of the chemists. When four centuries of search shall have been made in the world of chemical formation, then science should be ready to meet a congress of nations, to rejoice with the chemist upon the issue of his task.

It is well known that chemical labor has not been barren of returns. The products of chemical action, numbering thousands of thousands, have been sifted and measured and weighed. If you ask what happens in a common chemical change you can obtain direct answers. When coal burns in the air, how much oxygen is used up can be stated with a degree of exactness true to the first decimal of mass, perhaps to the second, yet questionable in the third. How much carbonic acid is made can be told in weight and in volume with approaching exactness. How much heat this chemical action is worth, how much light, how much electro-motive force, what train-load of cars it can carry, how long it can make certain wheels go round,—for these questions chemists and physicists are ready. With how many metals carbonic acid will unite, how many others it can make into carbonates, into what classes of molecules a certain larger fragment of carbonic acid can be formed, the incomplete records of these things already run through a great many volumes. These carboxylic bodies are open to productive studies, stimulated by various sorts of inquiry and demands of life. Such have been the gatherings of research. They have been slowly drawn into order, more slowly interpreted in meaning. The advance has been constant, deliberate, sometimes in doubt, always persisting and gradually gaining firmer ground. So chemistry has reached *the period of definition.* Its guiding theory has come to be realized.

"The atomic theory" has more and more plainly appeared to be the central and vital truth of chemical science. As a working hypothesis it has directed abstruse research through difficult ways to open accomplishment in vivid reality. As a system of knowledge, it has more than kept pace with the rate of invention. As a philosophy, it is in touch with profound truth in physics, in the mineral kingdom, and in the functions of living bodies. As a language it has been a necessity of man in dealing with chemical events. Something might have been done, no doubt, without it, had it been possible to keep it out of the chemical mind. But with a knowledge of the primary elements of matter, as held at the beginning of this century, some theory of chemical atoms was inevitable. And whatever theory might have been adapted, its use in investigation would have drawn it with a certainty into the essential features of the theory now established. It states the constitution of matter in terms that stand for things as they are made. The mathematician may choose the ratio of numerical notation, whether the ratio of ten or some other. But the chemist must find existing ratios of atomic and molecular mass, with such degree of exactness as he can attain. Chemical notation, the index of the atomic system, is imperfect, as science is incomplete. However defective, it is the resultant of a multitude of facts. The atomic theory has come to be more than facile language, more than lucid classification, more than working hypothesis, it is *the definition of the known truth in the existence of matter.*

The chemical atom is known, however, for what it does, rather than for what it is. It is known as a center of action, a factor of influence, an agent of power. It is identified by its responses, and measured by its energies. Concealed as it is, each atom has given proof of its own part in the structure of a molecule. Proofs of position, not in space but in action, as related to other atoms, have been obtained by a multitude of workers with the greatest advantage. The arrangement of the atoms in space, however, is another and later question, not involved in the general studies of structure. But even this question has arisen upon its own chemical evidences, for certain bodies, so that "the configuration" of the molecule has become an object of active research.

Known for what it does, the atom is not clearly known for what it is. Chemists, at any rate, are concerned mainly with what can be made out of atoms, not with what atoms can be made of. Whatever they are, and by whatever force or motion it is that they unite with each other, we define them by their effects. Through their effects they are classified in the rank and file of the periodic system. The physicists, however, do not stop short of the philosophical study of the atom itself. As a vibratory body its movements have been under mathematical calculations; as a vortex ring its pulsations have been assumed to agree with its combining power. As an operating magnet its interaction with other like magnets has been predicated as the method of valence. There are, as I am directly assured, physicists of penetration and prudence now looking with confidence to studies of the magnetic relations of atoms to each other.* Moreover, another company of workers,

*"The results of molecular physics point unmistakably to the atom as a magnet, in its chemical activities."—A. E. Dolbear, in a personal communication.

the chemists of geometric isomerism, assume a configuration of the atoms, in accord with that of the molecule.

The stimulating truth of the atomic constitution of the molecule, a great truth in elastic touch with all science, excites numerous hypotheses, which, however profitable they may be, are to be stoutly held at a distance from the truth itself. Such are the hypotheses of molecular aggregation into crystals and other mineral forms. Such are the biological theories of molecules polymerizing into cells, and of vitality as a chemical property of the molecule. Such are the questions of the nature of atoms, and the genesis of the elements as they are now known, questions on the border of metaphysics. Let all these be held distinct from the primary law of the atomic constitution of simple molecules in gaseous bodies, an essential principle in an exact science. The chemist should have the comfortable assurance, every day, as he plies his balance of precision, that the atom-made molecules are there, in their several ratios of quantity, however many unsettled questions may lie around about them. Knowledge of molecular structure makes chemistry a science, nourishing to the reason, giving dominion over matter, for beneficence to life.

Every chemical pursuit receives strength from every advance in the knowledge of the molecule. And to this knowledge, none the less, every chemical pursuit contributes. The analysis of a mineral, whether done for economic ends or not, may furnish a distinct contribution toward atomic valence. The further examination of steel in the cables of a suspension bridge is liable to lead to unexpected evidence upon polymeric unions. Rothamsted farm, where ten years is not a long time for the holding of an experiment, yields to us a classic history of the behavior of nitrogen, a history from which we correct our theories. The analysis of butter for its substitutes has done something to set us right upon the structure of the glycerides. Clinical inspection of the functions of the living body fain finds a record of molecular transformations too difficult for the laboratory. The efforts of pharmaceutical manufacture stimulate new orders of chemical combination. The revision of the pharmacopœia every ten years points out a humiliating number of scattered errors in the published constants on which science depends. The duty of the engineer, in his scrutiny of the quality of lubricating oils, brings a more critical inquiry into the laws of molecular movement.

There is not time to mention the many professions and pursuits of *men who contribute toward the principles of chemistry* and hold a share therein. If it be the part of pure science to find the law of action in nature, it is the part of applied science both to contribute facts and to put theory to the larger proof. In the words of one who has placed industry in the greatest of its debts to philosophic research, W. H. Perkin, "There is no chasm between pure and applied science, they do not even stand side by side, but are linked together." So in all branches of chemistry, whether it be termed applied or not, the best workers are the most strongly bound as one, in their dependence upon what is known of the structure of the molecule.

Studies of structure were never before so inviting. In this direction and in that especial opportunities appear. Moreover the actual worker here and there breaks into unexpected paths of promise. Certainly the sugar group is presenting to the chemist an open way from simple alcohols on through to the cell substances of the vegetable world. And nothing anywhere could be more suggestive than the extremely simple unions of nitrogen lately discovered. They are likely to elucidate linkings of this element in great classes of carbon compounds, all significant in general chemistry. Then certain comparative studies have new attractions. As halogens have been upon trial side by side with each other, so for instance, silicon must be put through its paces with carbon, and phosphorus with nitrogen. Presently, also, the limits of molecular mass, in polymers and in unions with water, are to be nearer approached from the chemical side, as well as from the side of physics, in that attractive but perplexing border ground between affinity and the states of aggregation.

Such is the extent and such the diversity of chemical labor at present that every man must put limits to the range of his study. The members of a society or section of chemistry, coming together to hear each other's researches, are better able, for the most part, to listen for instruction than for criticism. Still less prepared for hasty judgment are those who do not come together in societies at all. Even men of eminent learning must omit large parts of the subject, if it be permitted to speak of chemistry as a single subject. These considerations admonish us to be liberal. When metallurgical chemistry cultivates skepticism as to the work upon atomic closed chains, it is a culture not the most liberal. When a devotee of organic synthesis puts a low value upon analytic work, he takes a very narrow view of chemical studies. When the chemist who is in educational service disparages investigations done in industrial service, he exercises a pitiful brevity of wisdom.

The pride of pure science is justified in this, that its truth is for the nurture of man. And the ambition of industrial art is honored in this, its skill gives strength to man. It is the obligation of science to bring the resources of the earth, its vegetation and its animal life, into the full service of man, making the knowledge of creation a rich portion of his inheritance, in mind and estate, in reason and in conduct, for life present and life to come. To know creation is to be taught of God.

I have spoken of the century of beginning chemical labor, and have referred to the divisions and specialties of chemical study. What can I say of the means of uniting the earlier and later years of the past, as well as the separated pursuits of the present, in one mobile working force? Societies of science are among these means, and it becomes us to magnify their office. For them, however, all that we can do is worth more than all we can say. And there are other means, even more effective than associations. Most necessary of all the means of unification in science is the use of its literature.

It is by published communication that the worker is enabled to begin, not where the first investigation began, but where the last one left off. The enthusiast who lacks the patience to consult books, presuming to start anew all by himself in science, has need to get on faster than Antoine L. Lavoisier did when he began, an associate of the French Academy in 1768. He of immortal memory, after fifteen eventful years of momentous labor, reached only such a combustion of hydrogen as makes a very simple class experiment at present. But, however early in chemical discovery, Lavoisier availed himself of contemporaries. They found oxygen, he learned oxidation; one great man was not enough, in 1774, both to reveal this element and show what part it takes in the formation of matter. The honor of Lavoisier is by no means the less that he used the results of others, it might have been the more had he given their results a more explicit mention. Men of the largest original power make the most of the results of other men. Discoverers do not neglect previous achievement, however it may appear in biography. The masters of science are under the limitations of their age. Had Joseph Priestley lived in the seventeenth century he had not discovered oxygen. Had August Kekulé worked in the period of Berzelius, some other man would have set forth the closed chain of carbon combination, and Kekulé, we may be sure, would have done something else to clarify chemistry. Such being the limitations of the masters, what contributions can be expected in this age from a worker who is without the literature of his subject?

In many a town some solitary thinker is toiling intensely over some self-imposed problem, devoting to it such sincerity and strength as should be of real service, while still he obtains no recognition. Working without books, unaware of memoirs on the theme he loves, he tries the task of many with the strength of one. Such as he sometimes send communications to this association. An earnest worker, his utter isolation is quite enough to convert him into a crank. To every solitary investigator I should desire to say, get to a library of your subject, learn how to use its literature, and possess yourself of what there is on the theme of your choice, or else determine to give it up altogether. You may get on very well without college laboratories, you can survive it if unable to reach the meetings of men of learning, you can do without the counsel of an authority, but you can hardly be a contributor in science except you gain the use of its literature.

First in importance to the investigator are the original memoirs of previous investigators. The chemical determinations of the century have been reported by their authors in the periodicals. The serials of the years, the continuous living repositories of all chemistry, at once the oldest and the latest of its publications, these must be accessible to the worker who would add to this science. A library for research is voluminous, and portions of it are said to be scarce, nevertheless it ought to be largely supplied. The laboratory itself is not more important than the library of science. In the public libraries of our cities, in all colleges now being established, the original literature of science ought to be planted. It is a wholesome literature, at once a stimulant and a corrective of that impulse to discovery that is frequent among the people of this country. That a good deal of it is in foreign languages is hardly a disadvantage; there ought to be some exercise for the modern tongues that even the public high schools are teaching. That the sets of standard journals are getting out of print is a somewhat infirm objection. They have no right to be out of print in these days when they give us twenty pages of blanket newspaper at breakfast, and offer us Scott's novels in full for less than the cost of a day's entertainment. As for the limited editions of the old sets, until reproduced by new types, they may be multiplied through photographic methods. When there is a due demand for the original literature of chemistry, a demand in accord with the prospective need for its use, the supply will come, let us believe, more nearly within the means of those who require it than it now does.

What I have said of the literature of one science can be said, in the main, of the literature of the other sciences. And other things ought to be said, of what is wanted to make the literature of science more accessible to consulting readers. *A great deal of indexing is wanted.* Systematic bibliography, both of previous and of current literature, would add a third to the productive power of a large number of workers. It would promote common acquaintance with the original communications of research, and a general demand for the serial sets. Topical bibliographies are of great service. In this regard I desire to ask attention to the annual reports of the committee on Indexing Chemical Literature, in this association for nine years past, as well to recent systematic undertakings in geology, and like movements in zoology and other sciences. Also to the Index Medicus, as a continuous bibliography of current professional literature.

Societies and institutions of science may well act as patrons to the bibliography of research, the importance of which has been recognized by the fathers of this Association. In 1855, Joseph Henry, then a past president of this body, memorialized the British Association for coöperation in bibliography, offering that aid of the Smithsonian Institution which has so often been afforded to publications of special service. The British Association appointed a committee, who reported in 1857, after which the undertaking was proposed to the Royal Society. The Royal Society made an appeal to her Majesty's government, and obtained the necessary stipend. Such was the inception of the Royal Society Catalogue of scientific papers of this century, in eight quarto volumes, as issued in 1867 and 1877. Seriously curtailed from the generous plan of the committee who proposed it, limited to the single feature of an index of authors, it is nevertheless of great help in literary search. Before any list of papers, however, we must place a list of the serials that contain them, as registered by an active member of this Association, an instance of industry and critical judgment. I refer to the well-known catalogue of scientific and technical periodicals, of about five thousand numbers, in publication from 1665 to 1882, together with the catalogue of chemical periodicals by the same author.*

Allied to the much needed service in bibliography, is the service in compilation of the Constants of Nature. In the preface of his dictionary of solubilities, in 1856, Professor Storer said "that chemical science itself might gain many advantages if all known facts regarding solubility were gathered from their widely scattered original sources into one special comprehensive work." That the time of the philosophical study of solution was near at hand has been verified by recent extended monographs on this subject. In like manner Thomas Carnelley in England, and early and repeatedly our own Professor Clarke in the United States,† bringing multitudes of scattered results into coördination, have augmented the powers of chemical service.

What bibliography does for research, the Handwörterbuch does for education, and for technology. It makes science wieldy to the student, the teacher and the artisan. The chief dictionaries of science, those of encyclopedic scope, ought to be provided generally in public libraries, as well as in the libraries of all high schools.‡ The science classes in preparatory schools should make an acquaintance with scientific literature in this form. If scholars be assigned exercises which compel reference reading, they

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* Bolton's Catalogue of Scientific and Technical Periodicals (1885: Smithsonian) omits the serials of the societies, as these are the subject of Scudder's Catalogue of Scientific Serials (1879: Harvard Univ.) On the contrary Bolton's Catalogue of Chemical Periodicals (1885: N. Y. Acad. Sci) includes the publications of societies as well as other serials. Chemical technology is also represented in the last named work.

† The service of compilation of this character is again indicated by this extract from Clarke's introduction to the first edition of his "Constants" (1873): "While engaged upon the study of some interesting points in theoretical chemistry, the compiler of the following tables had occasion to make frequent reference to the then existing lists of specific gravities. None of these, however, were complete enough. . . ."

‡ The statistics of school libraries in the United States are very meagre, the expenditures for them being included with that for apparatus. For libraries and apparatus of all common schools, both primary and secondary, the annual expenditures is set at $987,048, which is about seven-tenths of one per cent. of the total expenditure for these schools.

will gain a beginning of that accomplishment too often neglected, even in college, how to use books.

The library is a necessity of the laboratory. Indeed, there is much in common between what is called the laboratory method, and what might be called the library method, in college training. The educational laboratory was instituted by chemistry, first taking form under Liebig at Giessen only about fifty years ago. Experimental study has been adopted in one subject after another until, now, the "laboratory method" is advocated in language and literature, in philosophy and law. It is to be hoped that chemistry will not fall behind in the later applications of "the new education" in which she took so early a part.

The advancement of chemical science is not confined to discovery, nor to education, nor to économic use. All of those interests it should embrace. To disparage one of them is injurious to the others. Indeed, they ought to have equal support. It would be idle to inquire into their respective advantages. This much, however, is evident enough, chemical work is extensive and there is immediate want of it.

Various other branches of science are held back by the delay of chemistry. Many of the material resources of the world wait upon its progress. In the century just before us the demands upon the chemist are to be much greater than they have been. All the interests of life are calling for better chemical information. Men are wanting the truth. The biologist on the one hand, and the geologist on the other, are shaming us with interrogatories that ought to be answered. Philosophy lingers for the results of molecular inquiry. Moreover the people are asking direct questions about the food they are to eat, or not to eat, asking more in a day than the analyst is able to answer in a month. The nutritive sources of bodily power are not safe, in the midst of the reckless activity of commerce, unless a chemical safeguard be kept, a guard who must the better prepare himself for his duty.

Now if the people at large can but gain a more true estimation of the bearing of chemical knowledge, and of the extent of the chemical undertaking, they will more liberally supply the sinews of thorough-going toil. It must be more widely understood that achievements of science, such as have already multiplied the hands of industry, do not come by chances of invention, nor by surprises of genius. It must be learned of these things that they come by breadth of study, by patience in experiment, and by the slow accumulations of numberless workers. And it must be made to appear that the downright labor of science actually depends upon means of daily subsistence. It must be brought home to men of affairs, that laboratories of seclusion with delicate apparatus, that libraries, such as bring all workers together in effect, that these really cost something in the same dollars by which the products of industrial science are measured. Statistics of chemical industry are often used to give point to the claims of science. For instance it can be said that this country, not making enough chemical wood pulp, has paid over a million dollars a year for its importation. That Great Britain pays twelve millions dollars a year for artificial fertilizers, from without. That coal tar is no longer counted a by-product, having risen in its value to a par with coal gas. But these instances, as striking as numerous others, still tend to divert attention from the more general service of chemistry as it should be known in all the economies of civilization.

It is not for me to say what supplies are wanted for the work of chemists. These wants are stated, in quite definite terms, by a sufficient number of those who can speak for themselves. But if my voice could reach those who hold the supplies, I would plead a most considerate hearing of all chemical requisitions, and that a strong and generous policy may in all cases prevail in their behalf.

If any event of the year is able to compel the attention of the world to the interests of research, it must be the notable close of that life of fifty years of enlarged chemical labor, announced from Berlin a few months ago. When thirty years of age, August Wilhelm von Hofmann, a native of Giessen and a pupil of Liebig, was called to work in London. Taking hold of the organic derivatives of ammonia, and presently adopting the new discoveries of Wurtz, he began those masterly contributions that appear to have been so many distinct steps toward a chemistry of nitrogen, such as industry and agriculture and medicine have thriven upon. In 1850 he opened a memoir in the philosophical transactions with these words "the light now begins to dawn upon the chaos of collected facts." Since that time the coal tar industry has risen and matured, medicine has learned to measure the treatment of disease, and agriculture to estimate the fertility of the earth. It seems impossible that so late as March of the present year, he was still sending his papers to the journals. If we could say something of what he has done we could say nothing of what he has caused others to do. And yet, let it be heard in these United States, without such a generous policy of expenditure for science as gave to Dr. Hofmann his training in Giessen, or brought him to London in 1848, or built for him laboratories in Bonn and Berlin, without such *provision by the State*, the fruits of his service would have been lost to the world. Aye, and for want of a like broad and prudent provision for research with higher education, in this country, other men of great love for science and great power of investigation every year fail of their rightful career for the service of mankind.

For the prosecution of research, in the larger questions now before us, no training within the limitations of human life can be too broad or too deep. No provision of revenue, so far as of real use to science, can be too liberal. The truest investigation is the most prudent expenditure that can be made.

In respect to the support that is wanted for work in science, I have reason for speaking with confidence. If I go beyond the subject with which I began I do not go beyond the warrant of the Association. This body has lately defined what its members may say, by creating a committee to receive endowments for the support of research.

There are men and women who have been so far rewarded, that great means of progress are in their hands, to be vigorously held for the best advantage. Strength is required to use large means, as well as to accumulate them. It is inevitable to wealth, that it shall be put to some sort of use, for without investment it dies. By scattered investment wealth loses personal force. The American Association, in the conservative interests of learning, proposes certain effective investments in science. If it be not given to every plodding worker to be a promoter of discovery, such at all events is the privilege of wealth, under the authority of this Association. If it be not the good fortune of every investigator to reach knowledge that is new, there are, every year, in every section of this body, workers of whom it is clear that they would reach some discovery of merit, if only the means of work could be granted them. Whosoever supplies the means fairly deserves and will receive a share in the results. It is quite with justice that the name of Elizabeth Thompson, the first of the patrons, has been associated with some twenty-one modest determinations of merit recognized by this Association.

"To procure for the labors of scientific men increased facilities" is one of the constitutional objects of this body. It is time for effectiveness towards this object. The association has established its character for sound judgment, for good working organization, and for representative public interest. It has earned its responsibility as *the American trustee of undertakings in science.*

"To give a stronger . . . impulse . . . to scientific research" is another declaration of what we ought to do. To this end larger endowments are necessary. And it will be strange if some clear-seeing man or woman does not put ten thousand dollars, or some multiple of it, into the charge of this body for some searching experimental inquiry now waiting for the material aid. The committee upon endowment is ready for consultation upon all required details.

"To give . . . more systematic direction to scientific research" is likewise stated as one of our objects. To this intent the organization of sections affords opportunities not surpassed. The discussions upon scientific papers give rise to a concord of competent opinions as to the direction of immediate work. And arrangements providing in advance for the discussion of vital questions, as formally moved at the last meeting, will in one way or another point out to suitable persons such lines of labor as will indeed give systematic direction to research.

In conclusion I may mention another, the most happy of the duties of the American Association. It is to give the hand of hospitable fellowship to the several societies who year by year gather with us upon the same ground. Comrades in labor and in refreshment, their efforts reinforce us, their faces brighten our way. May they join us more and more in the companionship that sweetens the severity of art. A meeting of good workers is a remembrance of pleasure, giving its zest to the aims of the year.

VOLCANIC DUST FROM OMAHA, NEBRASKA.*

By J. E. Todd, Vermillion, S Dak.

This material was from a stratum of whitish aspect, about 18 inches in thickness, found in the bluffs facing the Missouri river about 7½ miles north of Omaha. It has the same general characteristics as the volcanic dust which has been found in quantity along the Republican, in southern Nebraska, also in Knox, Cum-

*Proceedings of the Iowa Academy of Science, 1891.

ming and Seward counties in the same state. This statement is made on the authority of J. S. Diller, of the United States Geological survey, who has examined samples from all these localities microscopically. This differs in being stained with oxide of iron, and the sharp angular grains are coated with carbonate of lime. Like the rest it contains with the finely pulverized glass, a few rounded grains of quartz and angular grains of feldspar less than .02 of a millimeter in diameter. The dust is such as is carried through the air from volcanoes. The sand grains and occasional diatoms indicate its deposition in still water.

The following is a section of the bluff containing the volcanic dust stratum:

Twenty-five to thirty feet—Loess, exposed as much more on slope above.

Seven feet—Stratified yellow clayey loam, with many calcareous concretions.

One and one-half feet—Volcanic dust, stained with iron oxide.

Five feet—Yellow clayey loam, slightly stratified.

One-half foot—Fine gray sand.

Twenty feet—Coarse sand and pebbles obliquely stratified.

Fifteen feet—Unknown, probably in part blue till. Level of the Missouri river.

This locality is the most eastern exposure of the volcanic dust stratum which is found scattered over most of Nebraska. Diligent search has as yet failed to discover it on the Iowa side of the Missouri.

NEW DISCOVERIES AT BAOUSSÉ ROUSSÉ, NEAR MENTONE.

By the Marquis De Nadaillac.

I know of no discovery touching pre-historic times more remarkable than those made in the caves of Baoussé Roussé, between Mentone and Ventimiglia, on the borders of France and Italy. These caves were first discovered in 1872 by Mr. Rivière. Since that time this learned gentleman has vigorously prosecuted his excavations,* and they have yielded numerous human skeletons, all belonging to the celebrated Cro-Magnon race, who at the end of the Quaternary period, or perhaps at the beginning of

*They are related at length in "L'Antiquité de l'homme dans les Alpes maritimes." Paris, I. B. Baillière et fils, 1887.

neolithic times, ruled not only the south of France, but also all the Mediterranean shores. It is these same men we meet with under the names of Iberians, Ligurians, Sicanians, perhaps also under those of Pelasgians and Berbers. It is their bones that the brothers Siret found in the south of Spain, professor Sergi in Italy, and Mr. Rivière at Baoussé Roussé.

All the bones, wherever found, show a great similitude. They are robust, and bespeak an athletic constitution and a large muscular power. The men were remarkably tall, the crania are dolichocephalic, the tibias platycnemic, but since Dr. Manouvrier's observations, we cannot see there an inferior character. The cranium of the first skeleton found (an old man) measured 1,590 cubic centimeters. The cranium of the woman found next to him 1,450 cubic centimeters; but this last measurement is not quite accurate, on account of the decomposed state of the bones.

The man had upon his head a net of small shells (*Nassa neritea*), and bracelets of shells round his arms and legs. Near him Mr. Rivière collected more than 150 stone implements, and also numerous bones of mammals, birds, and fishes, evidently the food of these people.

New discoveries quickly followed the first ones, and we always find a particular mode of inhumation, which, I believe, still exists, or lately existed, in some Indian tribes. The bones of all the adults, after the total decomposition of the flesh, were painted in red with the help of peroxide of manganese or other substances frequently met with in the different caverns.

The last excavations took place in February, 1892, in one of these caves, named Barma Grande. A communication made to the Academie des Inscriptions, March 4, 1892, informed us of the discovery, at 8 metres below the level of the ground, of three new skeletons, a man, a woman, and a young subject whose dentes sapientiæ had not yet evolved. They had been buried on a bed of cinders, broken fragments of charcoal, remains of all sorts, evidently the hearth on which the family cooked their victuals. The boy wore a necklace formed of two rows of the vertebræ of a fish and one row of small shells. At different points hung pendants cut out of the canine teeth of stags, decorated with parallel striæ. The man had also a necklace of fourteen canines of the stag, also striated. With the skeletons were found a certain number of stone instruments, some of them finely worked, but none of them polished, and some bone implements of very gross fabrication.

The man was very tall, and, if we judge by the length of the thigh-bone (545 millimeters), his hight must have exceeded two metres (6 feet 6 inches). The boy, who had not yet attained his manhood, measured 1.63 metres (5 feet 8 inches). We must also remark the extreme wear of the teeth, very apparent already in the boy, and which in the man extended to their very root. I have already said that the caves of Baoussé Roussé yielded numerous bones of mammals, but none of them belonged to the extinct species, not even to the reindeer which is found in the south of France even at a late period. On the other hand, no polished stone implement was ever found in these caves. We can therefore give these men a pretty accurate date, and place their existence, as I have said, at the end of the Quaternary or the beginning of the neolithic times. One cave remains as yet unexcavated. It belongs to the Prince of Monaco. Orders are given that the excavations shall begin next spring. If they produce anything of interest, I will not fail to report them to the readers of *Science*.

Rougemont, Sept. 2. —*Science, Sept. 23.*

THE SHORE-LINES OF ANCIENT GLACIAL LAKES.*

By J. E. Todd, Vermillion, S. Dak.

As most are aware, there are areas of drift external to any terminal moraines, the origin of which is still in dispute. On general principles, it would be expected that numerous lakes would have frequently occurred during the Ice Age. As the ice advanced, streams would frequently be dammed, and their channels more or less changed, and the weight of the ice, with its chilling effect, in level areas would not infrequently produce a subsidence toward the ice, which would often become filled with the floods escaping from the ice.

Geike, in his "Ice Age," last edition, draws a graphic picture of such lakes in central North America. Inferences derived from the Merjelen sea, and similar lakes in the Alps, Greenland and the Himalayas, strongly urge the probability of much larger ones of the same kind during ancient times. Such have been found in

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side moraines upon the more recent drift. Lake Agassiz, and the lake of the Blue Earth region in Minnesota, and lake Dakota and James lake in Dakota, readily come to mind in this connection. But can similar lakes be recognized in the much eroded and fragmentary deposits external to the great terminal moraines? Some, as one with whom I was talking a few years ago, when discussing Prof. Wright's hypothesis of lake Ohio, said, "Glacial lakes are a delusion and a snare," yet the same person has mapped such a lake in central Wisconsin. Others would refer most of the extramorainic drift to this cause.

One difficulty, and one which some consider insuperable, is the absence of distinct barriers and shore-lines and old water levels. The beaches of lake Agassiz have been readily traced, but where are there any such traceable about lake Ohio or lake Missouri, or anywhere upon what has been called the older drift? The even, flat topography impresses one with lacustrine character in traversing the Blue Earth region, or that between Scotland and Mitchell, S. D.; but we can readily see that if a lake has been of transitory duration it would fail of producing a plain.

Before dwelling on a few recent observations, which it is the main purpose of this paper to present, let us consider briefly a few reasons for the common obscurity of the shore-lines of old glacial lakes.

1. The surface of such lakes would usually be very inconstant. The ice would have been a very uncertain barrier. The chance of depositing a beach or cutting a cliff would, therefore, have been small.

2. The accumulation of shore deposits would not only be slight, but being made largely by floating ice would be quite unequally distributed, especially in wide and shallow lakes. Prevalent winds would drive the drift-laden ice to certain shores much more than to others. If the lakes contained islands, the more remote shores might receive no erratics.

3. The difference in the ease of erosion between glacio-natant drift clays and the formations bordering them, may produce marked changes in topography and drainage. The regions of Dakota and Nebraska illustrate this well. Loose sands and easily eroded clays border the western edge of the compact and often boulder clad drift clays. While the latter are little affected by rains and streamlets, the former are rapidly removed. Moreover,

the former are peculiarly subject to sliding and slushing out at base. The amount of erosion which has taken place since the occupation of the earlier glacial lakes may be more perfectly realized when we learn that the prominent high terrace found along the Missouri, White and Cheyenne rivers is more than 300 feet above their present water level. This terrace dates from the time of the second moraine, or possibly of the first of the "second glacial epoch." And this terrace is much more recent than the lakes under consideration. An erosion, which has excavated these valleys to such a depth, must certainly have greatly changed the surface along the old lake borders.

4. Yet another influence may have frequently done much to mask lacustrine features, viz., orographic changes. Gilbert has recognized this as prominent in the cases of lakes Bonneville and Ontario. Chamberlin finds an elevation of Champlain deposits, of 330 feet in eastern Wisconsin, and of 5-600 feet in northwestern part of the same state. And this has been in a much less time than has elapsed since lake Missouri was filled with loess.

So much on general principle. As may be remembered the writer has held that the extra-morainic drift of the Missouri valley is probably of sub-aqueous origin, that lake Missouri which deposited the loess, at an earlier stage was partly filled with sand, gravel and boulder clay; that a similar lake occupied the Red Lake region, from the Bijou hills to the big bend. Also that a similar one covered a wide scope of country from near the mouth of the Moreau northward. Hitherto, I have found rather scanty evidence of an old water level in the distribution of boulders about the Bijou hills, 590 above the Missouri or 1,900 above the sea, and a patch of bouldery gravel and clay 510 feet above the Missouri, covering an acre or so, south of the mouth of White river.

In 1888 Prof. G. F. Wright reported the finding of something like a moraine along the divide south of the Moreau river. (See Proc. A. A. A. S., 1888.)

It has been my privilege the past season (1890) to traverse the course of Prof. Wright, with the same companion, Rev. T. L. Riggs, and to spend a few days in the examination of this feature.

I found Fox ridge a high sandy plateau, forming the divide between the Moreau and Big Cheyenne rivers. Upon it, and on its south slope, I found no northern erratics. Its summit, twenty miles west of the Missouri, is about 2,400 feet above the sea. Along its northern slope is a peculiar flat-topped, butte-like ridge running east and west for 15-20 miles, its top being nearly horizontal and about 50 feet lower than the summit of Fox ridge.

This was determined not only by several barometic readings, but by distant views from both north and south. The ridge is well covered with granite boulders, and drift 2-5 feet thick, but strange to say, no northern drift was found south of the ridge, except where its presence could be accounted for by recent transportation. The land just south of the ridge is frequently 50 feet lower than its top. This ridge is not strictly continuous. There is a wide gap, particularly, where it is crossed by the Virgin creek.

The margin of the drift I had not time to trace fully, but was informed by Mr. Riggs, who knows the region well, that it crosses the Moreau 25-30 miles west of its mouth and runs northward at about the same distance from the Missouri for an indefinite distance. Inside this margin the land nowhere rises higher than the margin, and it is here and there sprinkled with northern boulders, often in patches, especially on the higher levels. The divide between the Moreau and Grand rivers has an altitude of about 2,300 feet. Most of the surface is of Cretaceous clays, and is much eroded, the alternating layers of hard and soft material, producing an interesting topography, studded here and there with high, flat-topped buttes.

The course of the marginal ridge south of the Moreau is in line with some high clay buttes on the east side of the Missouri, just above the mouth of the Little Cheyenne, which are known as Welland buttes. They are strewn with a thin layer of boulders, and are the west end of a high divide separating the Little Cheyenne and Swan Lake creek. Crossing this divide is a well preserved ancient channel, more than 400 feet above the Missouri, and there are traces of an old terrace along the Missouri, near the Welland buttes, at about the same level.

Putting these things together, we come with some confidence to this conclusion: Fox ridge, with its eastern extension, the Welland buttes and the high land southwest of Bowdle and west of Faulkton, once formed the divide between the Cheyenne and Moreau rivers, when they flowed through to the James river valley. When the great ice sheet came down the latter valley during the glacial period, and occupied the outermost terminal moraine, there was for a time a great lake formed north of this Fox ridge divide. It was deep enough to float ice-floes and probably bergs from the edge of the ice sheet further north. These formed a bouldery beach along the margin, particularly along the southern side. Of the two outlets indicated, the western one cut down more rapidly, and formed part of the course of the Missouri. As erosion proceeded the bouldery margin became a ridge, because it yielded less rapidly to degradation than the soft clays and loose sands adjacent.

For this glacial lake we propose the name lake Arikaree, after the Indian tribe whose home formerly occupied a considerable portion of its area.

EDITORIAL COMMENT.

An Interglacial Chronometer; A Correction.

In an article in the August number of the Geologist (1892), entitled "An Approximate Interglacial Chronometer," is an obvious error. It is plain to anyone who carefully studies the map given on plate vi that the "interglacial gorge" which is represented to extend from the mouth of Bassett's creek, on the west side of the river, to the mouth of Nine-mile creek, should be continued, and actually was continued, further northward, and to the mouth of Rice creek, where the "pre-glacial gorge" is represented to begin. If the interglacial erosion began because the first glacial epoch displaced the river from any portion of its bed, the gorge that was the result of such interglacial erosion must have begun where the displacement began. The displacement began at the mouth of Rice creek, at that time, and not at the mouth of Bassett's creek. This will make the interglacial gorge extend, as the Trenton limestone is known on each side of the river to extend, to near the mouth of Rice creek, increasing the result that expresses interglacial time to about fifteen thousand years.

It was an oversight in the calculation, due to the use of an old map showing the gorge through the western limits of Minneapolis made in discussing the post-glacial recession of the falls of St. Anthony. The reader should understand the dotted lines that outline the interglacial gorge to be continued northward to the point where the pre-glacial gorge begins, and should substitute 15,000 years for 9,750.

A Mortuary Bitter-Sweet.

It is gathered from a recent obituary memoir that its subject in his youth was a good boy at school; neat and tidy; that he had a handsome forehead, lips well proportioned, and was crowned with fine hair; that he had a natural and very modest demeanor; that he was born to be a naturalist; that loyalty to truth and ingenuousness were shining features of his nature (sic): that he had the rare experience of living nearly sixty-eight years without making an enemy: that he proved himself an eligible candidate for a professorial chair; that he was elected "without competition" to the chair of president of an institution of Natural Sciences, which his biographer had held for a number of years before; and that at a meeting held after his death "ample testimony was adduced that he had attained distinction." This is the bright side of the picture, and all of it, except that which the writer puts in quotation marks as cited from other sources. But oh! how different it is with the other side! We learn that in youth he was distinguished for disobedience of his parents and playing truant; his early medical career was soon closed on account of neglect of duty and medical incompetency. It is further distinctly inferred, although not absolutely stated, that the pristine glory of the professorship of anatomy in the institution in which he filled that office was dimmed by his appointment. Even his father thought a good sign painter was spoiled to make a poor doctor. He was honored by being appointed a delegate of his university at two national meetings, without accomplishing anything for the credit of the institution. He delivered lectures to students on scientific subjects, seldom giving them the means of making useful application of his teachings in surgery and medicine; and he lectured and wrought for his university as a means of self maintenance, and because it was the principal source of his livelihood. He was a member of an important committee and a trustee of an important fund without attending to his duties.

A lady of social influence made him a lion and he had the temerity to resemble some of the paintings of his biographer's Saviour. At the age of sixty-five work and conviviality had abated his physical and mental powers, and he even wrote a line from which the interpretation could be extorted that he believed in the possession of an unknown power by a suspected charlatan. His works are principally anatomical and of little interest to others than votaries of natural history, owing to their lack of applicability to industrial use. Though deeply interested in botany, Prof. Porter did not think his knowledge profound, and in fact a determination of a species by the subject of the sketch was promptly shown to be fallacious and corrected by a lady at Bar Harbor. Though deeply interested in mineralogy from boyhood he was more than once taken in by dealers in minerals who wished to test his knowledge.

His head was small and his brain-weight below the average, which deficiency he probably compensated by good digestive apparatus. He called poetry "rhyming stuff," and adopted the ethics of John Fiske. One attribute of genius he shared with it—*i. e.*, sterility. No student of natural history was ever more assisted. After his death, representatives of his university solicited an immedtate contribution of $50,000 as an endowment fund, first to his widow and ultimately to revert to his university, but it is probable from the failure of the effort that the public has not judged the endowment urgent. * * * *

The reader will naturally ask of whom this gloomy account is given. Was he Prof. Webster the murderer of Parkman? On what stage did this evidently overvalued person perform? Above all, did he come to a good end? for with the natural perversity which his biographer pictures it is to be feared that he did not.

In answer let it be said that this singularly severe eulogy or friendly cacology is entitled, "A sketch of the life of Joseph Leidy, M. D., LL. D., by W. S. W. Ruschenberger, M. D.," and from the fact that its author has much experience and unquestioned success in preparing sketches of this kind (for which his indefatigable industry in the bibliography of his subject fits him), it is an example of the kind of history which one man can write of another who is his opposite in character and attributes; even when that writer is prepared by long service in a Philoso-Necrological Society. It is like a photograph of a bright landscape in monochromatic light; still, only for those few who are distinguished enough to invite the danger does it add a new terror to death.

The Topographical map of the United States.

The subject of the proper adjustment of the scientific surveys of the territories was submitted by Congress to the National Academy of Sciences in 1878. The Academy was requested to "take under consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Departments, and the surveys of the Land Office, and to report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the territories of the United States, on such general system as will, in their judgment, secure the best results at the least possible cost."

A committee of the Academy reported recommending two distinct bureaus or departments, under separate heads, one for surveys of mensuration, to include the Coast and Geodetic survey and the topographical work of the Land Survey office, and one for the determination of all questions relating to the geologic structure and natural resources of the public domain.

The sphere and duties of the latter were more fully defined: "The best interests of the public domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources and products. The domain embraces vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The committee therefore recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States geological survey, to be charged with the study of the geological structure and economic resources of the public domain; such a survey to be placed under a director, who shall be appointed by the president and who shall report directly to the Secretary of the Interior."

This report was favorably received, and the act of Congress which established the U. S. Geological survey (March 3, 1879), included in an act making appropriations for "sundry civil expenses" has the following words: "For the salary of the director of the geological survey, which office is hereby established, under the Interior Department, who shall be appointed by the president by and with the advice and consent of the Senate, six thousand dollars; *Provided*, That this officer shall have the direction of the geological survey, and the classification of the public lands, and the examination of the geological structure, mineral resources and products of the national domain, and that the director and members of the geological survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical survey of the Territories, and the Geological and Geographical survey of the Rocky mountain region, under the Department of the Interior, and the Geographical surveys west of the 100th meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth day of June, eighteen hundred and seventy-nine, and all collections of rocks, minerals, soils, fossils and objects of natural history, archeology and ethnology, made by the Coast and Interior survey, the Geological survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the national museum.

"For the expenses of the Geological survey, and the classification of the public lands and examination of the geological structure; mineral resources and products of the national domain, to be expended under the direction of the Secretary of the Interior, one hundred thousand dollars.

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"The publications of the Geological survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands and reports upon general and economic geology and paleontology. The annual report of operations of the Geological survey shall accompany the annual report of the Secretary of the Interior; all special memoirs and reports of said survey shall be issued in uniform quarto series if deemed necessary by the director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials received in exchange shall be the property of the United States, and form a part of the library of the organization; and the money resulting from the sale of such publications shall be covered into the treasury of the United States, under the direction of the Secretary of the Interior."

Mr. Clarence King, the first director, immediately took steps to extend the operations of the survey over the states as well as the territories. This was opposed strenuously, and failed in Congress on one or two occasions. But by changing the phraseology defining the purpose of the appropriation in the "Sundry Civil" bill, substituting "United States" for "national domain," the investigations of the Geological survey were authorized in 1883, to be carried on in the whole area of the United States. In lieu, however, of the previous definition of the duties of the survey the phraseology reads: "To continue the preparation of a geological map of the United States." There was no new act. The old duties were not abrogated, but something, not before authorized, is ordered to be "continued." Under this appropriation, thus illy and unwittingly introduced into the expenses of the Government, the U. S. Geological survey entered upon a vast undertaking. Not to be limited to the strictly geological duties that had been defined in the original law, the survey now organized a corps of topographic surveyors and engineers and began a rapid semi-geodetic survey for topographical mapping of the United States, as a basis for the contemplated geological map of its domains. For this work a large amount of the annual appropriation by Congress for the "geological map of the United States" has been expended. From year to year, for the past ten years the appropriation for a "geological map of the United States" has been taken to mean a continuance of all the original obligations and functions of the survey, and the conduct of a network of triangulation in various scattered areas in the country for later topographical mapping. This triangulation work has been filled in in several places, and maps have been constructed for geological purposes. Such maps are said to have cost sometimes one dollar, sometimes two dollars, and occasionally three or four dollars per square mile of the area mapped.

Congress took no action concerning the establishment of a mensuration survey, under the recommendation of the Academy of Natural Sciences. Prof. J. E. Hilgard, then superintendent of the Coast and Geodetic survey, seems not to have fully and fairly appreciated the situation. He neither took advantage of the favorable recommendation of the Academy of Sciences, in 1878, nor in 1884, when the subject was again being investigated, did he adequately represent the functions and the duties, present and prospective, of the Coast and Geodetic survey. Partly from necessity and partly from inclination, therefore, the topographical work of the U. S. Geological survey took on the characters and began the mapping which were the special prerogative and expected duty of the older survey. It is plain that the appropriations committee expected to make further recommendations intended to carry out the plan of the Academy of Sciences, because in the clause relating to the collections made by the various surveys they designated the Coast and Geodetic survey "the Coast and Interior survey," in keeping with a change proposed by the Academy's committee.

Soon came murmurs of duplication and clashing of official functions between the two surveys. This became so loud and so patent that Congress created a "joint commission" to examine into the scientific work of the government more widely. This commission was appointed July 7, 1884, and continued its investigation until 1886. It again consulted the National Academy of Science, and that body recommended the creation of a governmental "Department of Science," to coordinate and include the Coast and Geodetic survey, the Geological survey, and the meteorological work of the Weather bureau. Such recommendation, however, was not received cordially, and never went into effect. Since then the Weather bureau has been transferred from the War Department and given in charge, as a civilian bureau, to the new Department of Agriculture; the Geological survey has continued to "make preparations for a geological map of the United States," and the Coast and Geodetic survey, besides its transcontinental triangulation, has cooperated with various States in the construction of topographical maps, and has done its usual coastwise work. There was no coordination of the work of the two surveys. The duplication is as flagrant as is possible under the courteous handling of two intelligent chiefs.

It is time, however, that such waste of treasure and of energy be stopped. There are two series of independent triangulation being spread over the United States, each designed to prepare for topographical mapping. They are not bound to articulate with each other, nor to agree with each other. If they are both carried to completion there will be two sets of topographical maps. It is true that the area is so large within which they can operate that they do not yet violently impinge on each other. The States that elect to cooperate with the Coast and Geodetic survey in the construction of their topographical maps, now some fifteen or twenty in number, are, for the most part, let alone, in this regard, by the U. S. Geological survey, while those which have attempted to use the topographical sheets of the U. S. Geological survey have been compelled, in some instances, to abandon the attempt and to construct new sheets from independent triangulation — or at least from different data—or they have made geological maps without extensive topographic data.

We do not hesitate to say that it was a serious and far-reaching mistake when the U. S. Geological survey, contrary to the recommendation of the National Academy of Science, and in addition to the great work it had on hand in the examination of the geological structure and the natural mineral resources of the country, entered upon the geodetic and topographical surveying of the national domain. In brief, our reasons for this opinion are:

1. There was already in existence fully equipped an efficient organization engaged in such work. It only needed reenforcement and authorization, to have performed this topographical work for the whole country with correctness and dispatch.

2. The duties of the Geological survey, as defined in the congressional acts relating to it, are ample for the functions of one bureau.

3. We know of no precedent for it: but so far as example goes its influence would be opposed to it. The topographical mapping done by the early territorial surveys was discontinued by act of Congress, and no state survey had, at that time, entered upon topographical mapping under a law ordering simply a geological survey. The British Geological survey does no topographical mapping, but receives such maps from the Ordance Department.

4. The country demands more accurate work in geodetic measurements and more exact mapping than the Geological survey professedly aims to perform. A good topographical map, such as those constructed by the Coast and Geodetic survey, while costing perhaps ten dollars per square mile, is what the country needs and must have, and would answer many other purposes than for the mere delineation of the geological structure. It would be of service in the Post Office Department, the Land Office, the Weather bureau, and especially in the War Department. All economic and industrial, not to say educational affairs would be aided by such a map. On the contrary the topographical

maps now being constructed by the Geological survey, are not claimed to be suited for anything else than geological purposes, and are not distributed as topographical maps. They would not do credit to the country should they be distributed as such; and it may not be too much to say that ultimately they will be discarded even for geological purposes; and the geological structure will have to be delineated again on more accurate maps.

5. The diversion of the funds provided for the *geological survey* of the United States into the construction of a topographical map. It may be said, with a semblance of truth, that a correct geological map cannot be made without a previous topographical map. But the word *correct* here is susceptible of shades of meaning. Many "correct" geological maps have been made without any previous topographical mapping. For the purposes for which the geological survey was created, very simple maps could be constructed, and, as defined in the original law, they would "illustrate the mineral resources and the classification of lands."

6. However necessary a topographical map may be to a geological map of the United States, it was not contemplated in the act of Congress which established the Geological survey, nor in subsequent appropriations till 1886, when the appropriation was made after a lengthy investigation, when the affairs of the Coast and Geodetic survey were in a very unsettled condition; and when the Geological survey, under the impetuous lead of an energetic director, had secured from a committee of the National Academy of Science a recommendation not to disturb the *status quo* of the survey.

Both these surveys now are adequately manned, and we are confident that the plan of the National Academy of Science should be fully carried out by such legislation as would transfer the entire outfit and all the employés of the topographical branch of the Geological survey to the "Coast and Interior survey," and the whole to the Department of the Interior. There should be such coordination that in no case would there be a duplication of the work. The Geological survey should follow the work of the mensuration survey — so far as its mapping is concerned — and in the meantime it should concern itself with the investigation of such scientific and economic problems as the geology of the country presents — and they are myriad.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Third Annual Report of the Geological Survey of Texas, 1891. E. T. DUMBLE, State Geologist. Austin, 1892. 8vo, 410 pp.

Besides the general administration report of Mr. Dumble, this volume embraces the following papers:

Houston County, by W. Kennedy.

Section from Terrell to Sabine Pass. W. Kennedy.

Llano estacado or staked plains. W. F. Cummins.

Notes on the geology of the country west of the plains. W. F. Cummins.

Stratigraphy of the Triassic formation in Northwest Texas. N. F. Drake.

Report on the paleontology of the vertebrata. E. D. Cope.

Shells collected in a dry salt lake near Eddy, New Mexico, by V. Sterki.

Reports on the Cretaceous area north of the Colorado river. J. A. Taff.

Trans-Pecos Texas. W. H. Von Streereewitz.

Of these, the papers that possess the greatest general interest are those of Mr. Taff and Mr. Cummins. Mr. Cummins made the entire circuit of the area of the "staked plains" and at their western bound he left them for a short trip into New Mexico, following the old route of travel where Mr. Jules Marcou passed in 1853 in the service of the United States in the survey of the line for the Southern Transcontinental railroad. The age of the beds of Tucumcari has been a matter of dispute ever since the report of Mr. Marcou, who made them Jurassic. [See a review of the subject in the AMERICAN GEOLOGIST, Vol. iv, Sept., Oct., 1889.] Mr. Marcou's determination has been sustained by Capt. C. E. Dutton, Prof. A. Hyatt and Prof. Robt. T. Hill, but opposed by Prof. James Hall and Dr. J. S. Newberry. Mr. Cummins collected a great number of fossils from the vicinity, but they have not yet been thoroughly studied. He, however, gives a list which have been identified with Cretaceous species.

The following is a list of fossils collected by him from the beds in dispute "in the vicinity of Tucumcari and Pyramid mountains:"

Gryphæa dilatata, var. *tucumcari* Marcou.
Ostrea marshii as determined by Marcou.
Gryphæa pitcheri Morton.
Exogyra texana Roemer.
Ostrea quadriplicata Shumard.
Trigonia emoryi Con.
Cardium hillanum Sow.
Cytherea leonensis Con.
Turritella seriatim-granulata Roem.
Pinna sp.
Ammonites.
Pecten.

With the exception of the first two these have been referred repeatedly to the Cretaceous (Washita and Fredericksburg divisions) in Texas.

The discovery in the same strata of a fossil angiospermous plant, which Mr. Cummins figures and describes under the name *Sterculia drakei* is considered sufficient evidence of the Cretaceous age of the strata from which it came.

The sections here compared and thought to belong to the Cretaceous are as follows:

Pyramid Mountain by MR. MARCOU.

1 White limestone	2	feet
2 Yellow limestone	50	"
3 Blue clay	30	"
4 White sandstone	25	"
5 Yellow sandstone	80	"
6 White sandstone	8	"
7 Grayish blue clay	1	"
8 Variegated marls	500	"
Total	696	feet

Tucumcari mountain by MR. CUMMINS.

1 White clayey limestone	20	feet
2 Massive sandstone	60	"
3 Shale (blue clay? N. H. W.)	50	"
4 Massive yellowish sandstone	235	"
5 Red sandstone	30	"
6 Blue clay	4	"
7 Purple clay	6	"
8 Arenaceous clay	1	"
9 Blue clay	4	"
10 Purple clay	16	"
11 Light red clay	30	"
12 Dark red clay	145	"
Total	601	feet

These sections are about ten miles apart, according to Mr. Cummins, but they are found in a region that embraces several other similar hills all of which are referred by both Cummins and Marcou to the same geologic horizon. If we understand, contrary to the statement of Mr. Cummins,* but apparently in harmony with his general argument, that the "blue clay" horizon (No. 3 above, of Marcou) is the stratigraphic equivalent of his "shale" horizon (No. 3, of his Tucumcari section), and not of his No. 6, and ignore the enormous thickening of Mr. Cummins' No. 4 (his supposed Trinity sands), these sections present a reasonable degree of stratigraphic resemblance. We infer also, as argued by Mr. Cummins, that in Mr. Marcou's section the word "limestone" in No. 2 is a misprint for *sandstone*. The thickening of the sandstones of Cummins' No. 4, which may be considered the equivalent of Marcou's Nos. 4, 5 and 6, is not an unwonted circumstance in the composition of coarsely fragmental formations.

The settlement of the disagreement will have to depend on the fossils. In the light of the fossils named by Mr. Cummins, the beds seem to belong to the lower Texas Cretaceous, but the question is not settled whether the lower Texas Cretaceous, particularly the Trinity sands, is Cretaceous or Jurassic. Mr. Hill, who revolutionized the Cretaceous in Texas by adding to it the Comanche series including this member, has given a list of its molluscan fossils in his Arkansas report,† remarking that they bear "remarkable resemblance to forms from the upper Purbeck and basal Neocomian or Wealden beds of Europe." Mr. Marcou has reviewed this list of fossils‡ and made such changes in the identifications that they are all made to appear Jurassic. In short, Mr. Marcou

*"The only blue clay bed in the vicinity is that in which the fossil zone of the *Gryphæa dilatata* var. *tucumcari* occurs." p. 202.

†*Neozoic Geology of southwestern Arkansas. Chapter xiii.* Annual report of the Geological Survey of Arkansas for 1888, Vol. II, 1889.

‡AMERICAN GEOLOGIST, Vol. IV, Dec., 1889, pp. 357-367.

affirms that the Trinity division of the Comanche of Hill, is the equivalent of the upper, and perhaps of nearly all of the European Jurassic. These Trinity sands being below the Tucumcari beds (*i. e.* below the blue clay containing the *Gryphæa dilatata*, var. *tucumcari* Marcou), must belong to the Jura provided the Tucumcari beds belong there; and, per contra, the Tucumcari beds must fall into the Cretaceous if the Trinity sands belong there. Now Mr. Cummins refers his fossils to the "Tucumcari beds" as he has defined them, *i. e.* to some sandstones that are actually above the horizon of *Gryphæa dilatata*, var. *tucumcari*, and he paralletizes them with higher portions of the Comanche, viz., with the Washita and Fredericksburg divisions. It seems quite likely that Mr. Cummins is correct in assigning those upper strata to the Cretaceous but the chief point of contention of Mr. Marcou, touching the underlying strata, viz., Mr. Marcou's E, D, C, and B, or Mr. Cummins' Nos. 4 and 5, seems not exactly disproved, and these may still remain in the Jurassic, at least until Mr. Cummins defines more closely in what portions of his Tucumcari beds he found his fossils.

Mr. Cummins' report is a very valuable one, and bears strongly *prima facie* against the Jurassic in Pyramid mountain.

Mr. Taff's report on the Cretaceous area north of the Colorado river agrees with that of Mr. Cummins in placing the Trinity sands in the Cretaceous, and he gives a diagram (p. 292) illustrating the unconformable position of Bosque Cretaceous upon the paleozoic, with the "Trinity phase" at the bottom. The Trinity sands proper he shows are not an individual entity in the stratification, but are closely knit with the Glen Rose and Paluxy, these making a three-fold formation which he distinguishes as the Bosque division. Overlying the Bosque division are the Fredericksburg and the Washita divisions. It is a noteworthy distinction that Mr. Taff only finds the *Gryphæa pitcheri* and the *Exogyra texana*, characteristic fossils of the Cretaceous, in the upper divisions (p. 281). "The lowest limit of these fossils marks the upper limit of the Bosque division."

In the Bosque division is a different fauna, but few members of which extend into the higher divisions. In addition to the *Gryphæa dilatata*, var. *tucumcari* Marcou, which Mr. Cummins admits cannot be the same as the *G. pitcheri* of the Cretaceous, and which is a fossil characteristic of the European Jurassic, and the *Ostrea marshi* which Mr. Cummins has not had opportunity to compare with European fossils of that name, both of which may be referred to the Bosque division. Mr. Taff enumerates the following fossils from this division.

1. In the *Trinity* sands; Trigonia, Ammonites, "Ostrea beds," (p. 295); Ostrea franklini (pp. 297 and 310); Ostrea camelinis (Ms. of Cragin), pp. 303 and 307; Trunks of trees much silicified, also changed to lignite, constituting veritable driftwood, (p. 310).

2. In the *Glen Rose* member; Monopleura, Goniolina, Caprotina (Requienia) penguiuscula, Exogyra, Ostrea, Arca. Ostrea subquadrata (pp. 297-299); "Arca and small Ammonites, allied to A. pedernales Roemer, and Nerinea occur abundantly in the marly line," *i. e.* in Glen Rose (p. 304); Ostrea camelinis Cragin (p. 307); O. franklini (p. 310); Cardium

mediale, Natica, Cyrena, Goniolina (p. 313); Anomia (p. 315); Turritella, Cardium mediale and C. hillanum, Pleurocera, Serpula, Trigonia crenulata (pp. 316, 317); Cardium mediale (p. 337).

3. In the *Paluxy* member; no fossils are named from the Paluxy.

These Trinity fossils can none of them be pronounced Cretaceous by reference to any undoubted standard of comparison. The genus Trigonia ranges from the Lias to the Chalk, Ammonites from the Oolite to the present. Ostrea franklini was placed in the Cretaceous by Coquand without any authority whatever, except a surmise by Mr. Marcou that it was obtained "somewhere near the locality of Gryphæa pitcheri." It was published in the Arkansas geological report of Owen by Mr. E. T. Cox, without any description, only the illustrated plates having been found after Owen's death.* Ostrea camelinis, of the manuscripts of Prof. Cragin, being a new species has no authority as a guide to the age of the strata containing it.

In the Glen Rose member, which by Prof. Hill was not associated with the Trinity but was retained in the Fredericksburg division, the reported species are more affiliated with the Cretaceous, but there is not yet sufficient volume of a distinctively Cretaceous fauna to carry its assignment to that age beyond the limit of doubt. A large fauna is given the Fredericksburg division by Prof. Hill, but it is uncertain what part of it belongs in the Glen Rose division, detached from the Fredericksburg by Mr. Taff and placed in the Bosque division, but it appears to be but a meager portion of it—probably that which Mr. Hill has embraced in his "basal beds" of the Fredericksburg division. However, Mr. Taff mentions:

Monopleura, may be either in the "basal beds" or the Caprina limestone of Hill.

Goniolina, in magnesian limestone, with bivalves and gasteropods.

Caprotina (*Requienia*) *penguiuseula*, apparently a fossil of the "lower beds" and of the Caprina limestone. The genus is found in the upper Greensand of France.

Exogyra, in the basal, alternating beds. The genus also is found much higher, as well as in the Jurassic.

Ostrea, ranges from the Jurassic upward.

Arca, ranges from the Trinity sands to the Washita division.

"*Ostrea subquadrata*." Thin bedded limestone. Not mentioned by Hill.

Ammonites. Ranges from the Lias to the Chalk. Hill gives A. pedernalis Von Buch, in the Comanche Peak chalk.

Nerinea, is a Jurassic genus.

Ostrea camelinis ms. of Cragin. From the Trinity to the Glen Rose.

Ostrea franklini Coq. is abundant in the Trinity.

Cardium mediale. Is given by Hill only for the Comanche Peak limestone, which is next above the "lower beds," but Mr. Taff found it immediately above the Trinity sands, and therefore at the base of the alternating or "basal beds."

Natica. Ranges from the Devonian to the present time.

Cyrena. A fossil of the Wealden, ranging upward.

*This is on the statement of Mr. Marcou, AMERICAN GEOLOGIST, vol. IV, p. 359, 1889.

Anomia, is a common fossil of the upper beds of the Jurassic. Mr. Hill gives only one species (ind.) in this uncertain horizon, and that is in the Trinity sands.

Turritella. Is a good Cretaceous genus, and if correctly identified goes far to prove the Cretaceous age of these beds. Mr. Hill has it running from the "lower beds" of the Fredericksburg division to the Navarro beds in the upper Cretaceous.

Cardium hillanum. Also ranges from the Jura to the Chalk.

Pleurocera. Found also in the Trinity (Hill). May be a Cerithium or a Nerinea, both Jurassic genera (Marcou).

Serpula. Basal beds. Not mentioned by Hill.

Trigonia crenulata. According to Hill ranges from the "basal beds" to the Comanche Peak chalk.

The Glen Rose member is wedge-shaped and runs out toward the west allowing the Paluxy to lie directly on the Trinity, when the Paluxy is preserved. In other cases both the Glen Rose and the Paluxy are wanting, and the "Texana bed," of the Fredericksburg division, then comes immediately into superposition on the Trinity of the Bosque division.

Notwithstanding this break in the order of stratification, which, however, Mr. Taff does not seem to consider an unconformity of the Fredericksburg on the Bosque, but rather an incident of continuous sedimentation, and notwithstanding the partial alliance of the fauna with the Jurassic, and the non-characteristic features of the other fossils he has named, Mr. Taff assigns the Bosque to the Cretaceous on the following grounds:

"That the Trinity sand is Cretaceous and represents the littoral deposits of a part of the lower Cretaceous series, has evidence in the facts that its beds abut against the pre-Cretaceous continental contour; that its beds conform to and blend with the undoubted Cretaceous Glen Rose limestones; that its component materials are local, and have their origin in the paleozoic as a strictly near-shore rock; and further, that it contains fossil fauna and flora that range through superimposed beds of sand and limestone."

There is, however, room to question whether the Glen Rose is "undoubted Cretaceous," and whether all the other "facts" mentioned would not hold true of the Jura, in case the Jura were supposed to extend to the summit of the Bosque division, or at least to the summit of the "lower beds" of Hill.

We know nothing of this subject from studies in the field. We take the facts and all the evidences as they are given by others. We have endeavored to call attention to the principal point of difference between Mr. Marcou and Messrs. Cummins and Taff, and we are constrained to conclude that the question is still an open one. Mr. Cummins' fossils seem to be from strata that lie above the actual Tucumcari stratum, although still embraced in beds which Mr. Marcou placed in the Jurassic--indeed Mr. Cummins admits that he "did not find the Cretaceous fossils below the Gryphæa [tucumcari] beds." Therefore they were from strata above, and as some of them are identical with those which

Mr. Taff finds in the Fredericksburg division, associated with *Gryphæa pitcheri*, they have no bearing on the strata which Mr. Marcou claims have unimpeachable evidence of Jurassic age. He did in his original paper represent the whole of Pyramid mountain as Jurassic, above his stratum E, but he has not claimed, so far as we have learned, that any strata containing the Fredericksburg or Washita fauna are of Jurassic age. In Pyramid mountain these upper strata afforded him no fossils, and his assignment of them to the Jurassic was based apparently largely on topographic considerations. Mr. Cummins' argument can only apply to these upper strata, and he seems to have proved, by the aid of Mr. Taff, who has defined the position of his fossils more exactly, that they are not in the Jurassic.

By this report, of which other chapters, though perhaps equally meritorious, no special mention can be made here, it is seen that the Texas survey is making substantial and even rapid progress in the field-work, and is elucidating the geology of a large and interesting and difficult section of the union. The ensemble of the volume is very creditable, the illustrations and maps are excellent. We only notice occasionally in Mr. Cummins' report, an ungrammatical use of the word "strata," which cannot be wholly the fault of the proof-reader.

Some New Species and New Structural Parts of Fossils. By S. A Miller and Charles Faber. (Jour. Cin. Soc. Nat. Hist., Vol. xv, No 2, July, 1892.) In this paper the authors describe as new eight paleozoic species of fossils under names and from rocks as follows: *Modiolopsis corrugata*, *M. longa*, *M. sulcata*, *Orthodesma mundum*, *Protoscolex magnus*, and Cyclocystoides cincinnatiensis, from the Hudson River group of Ohio, *Holocystites affinis* from the Niagara group of Indiana, and *Aviculopecten germanus* from the Coal Measures of Kentucky. Besides, the under side of a specimen believed to belong to *Agellacrinus pileus* is described and new details of structure are brought out. The paper is accompanied by a plate containing eighteen figures.

A critical examination into the merits of the new forms seems to show a too great confidence of the authors in the obviousness of the peculiarities of their species. We miss, namely, sufficient comparisons with related species, a criticism that may justly be made on most of Mr. Miller's really valuable previous productions. As a rule we regard it as not only good practice but almost a necessity for the author of a new species to supplement his description with full comparisons with related species, since these are a great aid in the always difficult task of identification. For instance, it would have been most desirable to learn from the authors just in what respects their *Modiolopsis corrugata* differs from the similarly marked *M. pholadiformis* Hall, and *M. capax* Miller. As it is, we must confess that we are strongly inclined to doubt that these three names stand for as many good species.

M. longa agrees in a general way with *M. oblonga* and *M. subparallela* of Ulrich, but seems to be even more elongate and with the point of greatest convexity nearer the posterior end. On the other hand, there are points in the description and figure that cause us to think it possible that their specimen is not a true *Modiolopsis*, but rather an *Orthodesma*.

M. sulcata seems to be a sharply distinguished species, but the *Orthodesma mundum*, as illustrated, has a general expression decidedly like *Modiolopsis anadontoides*, *M. cincinnatiensis* and other species of that type. The illustrations of these shells have evidently been drawn by one unaccustomed to do natural history work. The specific characters are rather indefinitely brought out, and reasonable restorations of outline, perfectly justifiable, might have been attempted with profit.

We fail to see any grounds whatever for separating *Protoscolex magnus* from Ulrich's *P. ornatus*, since the claim that their species is larger than his rests upon a misapprehension. In all other respects they are identical, and Ulrich's measurements indicate a size scarcely if at all inferior to those given for *P. magnus*.

As to the merits of *Cyclocystoides cincinnatiensis* and *Holocystites affinis*, little can be said, since they belong to genera of which very different opinions prevail respecting their specific variability. According to our experience, species of these genera are numerous enough, but individuals of the species seem to be rare.

Geological Survey of Missouri, ARTHUR WINSLOW, state geologist, *The Higginsville sheet, in Lafayette county.* 17 pp. folio, map and page of geological sections. Published by the Geological Survey, Jefferson City, April, 1892.

This report and map, and the plat of sections, are based on good work, and they are finely executed, *for their kind.* But their kind is very bad. It has been, and is still, to some extent, the practice of state geological surveys to publish large maps, or large sheets of larger maps, which are enclosed in a roll, or in a case which is entirely separated from the descriptive report. The two get far separated, and generally the maps become lost, or at least greatly damaged by the difficulties of handling. Thus the value of the reports themselves is lessened or lost. We instance the late publications of New Hampshire, Ohio and Wisconsin. Prof. Winslow has endeavored to obviate this inevitable separation and damage by printing the report on the same sized page as the large map and issuing them together as one document. But in our opinion he has only increased the objections to the large folio (or sheet) size of publication They will of course not become separated, thus bound in one cover, but the common user of such reports will have the trouble of handling such a sheet many times increased. Common library shelves will not accommodate such a document, and yet it should be in as ready reach as a book on a library shelf. We like the plan of the Minnesota and Pennsylvania surveys (2d survey) which is the converse of this, viz: The maps are planned to be the size of the book-page (large quarto) including only a county on each. These are bound into the book and are inseparable from it, and are always handy to consult whenever the report is read, and being of ordinary size the maps and the text can always be kept in convenient place with other books; and the maps themselves when they are all made, can be bound together separately in form of an atlas with briefer accompanying descriptions, if desired. In other words we should make *the county* the unit of mapping, just as it is the civil and geographic unit, and if the scales differ it is of no moment, since generally, especially in all western states, the townships are cut by section lines which on the face of the map constitutes a *scale of miles* for every map. Thus the map is always handy and will last as long as the book itself.

Stratigraphy and Succession of the Rocks of the Sierra Nevada of California. By JAMES E. MILLS. Bulletin of the Geological Society of America, Vol. III, pp. 413-444, with map; Aug. 8, 1892. This description of the northern portion of the Sierra Nevada between the North and Middle forks of Feather river is a summary of the author's observations during many years as a mining engineer. The accompanying map shows the rock formations on the greater part of an area of six townships from east to west and four from north to south, lying in Plumas county, immediately southwest of the Taylorville district and Mt. Jura, which have been described in the same volume by Diller and Hyatt, as noticed in the September GEOLOGIST (p. 183). In this northern part of its extent the Sierra is double, consisting of eastern and wes'ern divisions, the latter being in the course of continuation of the axis of the Cascade range, to which it is nearly related by its geologic features. Barometric measurements in the district mapped give the hight of Grizzly ridge, in the eastern division, as 7,952 feet above the sea; of Spanish peak, the culminating point of the western division, 6,990 feet; and of an intermediate mountain called Claremont, 6,962 feet. Contiguous valleys are between 3,000 and 4,000 feet. The northern end of the Sierra Nevada rises thus only about half as high as Mt. Whitney and other peaks near its southern end.

The present altitude of this mountain range is ascribed principally to Tertiary and Quaternary uplifts by faulting; but the axes of greatest uplifting coincide approximately with those of previous ranges within the same area. "Repeated orographic movements have taken place along the same axes, and recurring uplifts along these axes have followed recurring erosion. In this way a pre-Mesozoic range arose, carrying up both crystalline and metamorphosed sedimentary rocks, and partially disappeared through erosion and subsidence; then a Mesozoic range arose and its strata became uptilted, and it in turn was reduced by erosion and subsidence to very small proportions (in its northern half, at least, nearly or quite to base-level of erosion); and then in Tertiary and Quaternaiy time has arisen the present range, which is now undergoing its erosion, but whether it is now rising or subsiding is not determined."

Granites form the greater part of the pre-Mesozoic rocks of the Sierra Nevada, making up the core of the range and of each of its two northern divisions; and they are overlain by metamorphic slates and quartzites, which may represent several Paleozoic periods.

The metamorphic Mesozoic rocks belong to the Jurassic and Cretaceous periods and comprise an apparently conformable series of sediments and lavas several miles thick. The sedimentary rocks are principally slates, often altered to quartzites, with some limestones. In the lower part of this series the principal eruptives are diabase and greenstone, products of alteration of moderately basic lavas; and in the upper part, where the lavas were very basic, they are more or less completely altered to serpentines.

The prevailing strikes are parallel to the general trend of the range and of the coast; and the dips are mainly between 60° and vertical. Mr. Mills has not observed curving folds, and therefore concludes that the strata at the time of their tilting experienced much shearing on approximately horizontal planes of overthrust, and that the subsequent upheavals have been chiefly by the faulting of mountain blocks. Neither has he found any unconformity of dip and strike between the pre-Mesozoic and Mesozoic groups of metamorphic strata; but they were doubtless separated by a long period of erosion and subsidence. Upper Cretaceous (Chico) and Tertiary beds at the western foot of the range dip westward at low angles, indicating that the greater part of the tilting and metamorphism took place during some stage of the Cretaceous period, which Becker, from his study of the few fossiliferous horizons, believes to have been at the close of the Gault epoch. The tilting was attended with much fissuring and the formation of veins of gold-bearing quartz and pyrite.

The Geology of the Crazy Mountains, Montana. By J. E. WOLFF. Bulletin, G. S. A., Vol. III, pp. 445-452; August 8, 1892. The Crazy mountains, an isolated range 40 miles long from south to north with a width of 15 to 20 miles, lie about 30 miles east of the easterly border of the main range of the Rocky mountains, and attain an elevation of 11,000 feet above the sea, the difference in level between their summit and base averaging perhaps 4,000 feet. They lie close north of the Yellowstone river, and are conspicuously seen from the Northern Pacific railroad for many miles eastward from Livingston. In structure they are comparatively simple but unique, being probably, as noted by Upham, the best known example of the type of mountain ranges which have not been made by any definite process of mountain-building but are simply remnants of extensive uplifted areas that have been deeply eroded.

Nearly horizontal Cretaceous rocks form the principal mass of the range and reach far eastward in the great plains and westward to the frontal line of the Rocky mountains, where sharp uplifts expose the older rocks. The strata of the Crazy mountains consist of sandstones and occasional conglomerates, interstratified with shales, and appear to be wholly referable to the latest Cretaceous or Laramie epoch. Eruptive dikes in wonderful profusion and variety cut these strata; and intrusive lava sheets and laccolites, up to a thickness of 365 feet, are interbedded with them, but no evidence of surface flows has been found. The more enduring igneous rocks preserved this range, while denudation to the vertical depth of nearly a mile reduced all the surrounding country to a base-level.

The head stream of Shields river, a tributary of the Yellowstone, has cut a deep valley in the western side of the range, dividing it into southern and northern halves. The southern part, which is the higher, has numerous sharp, jagged peaks, from which the streams flow radially outward to the west, south, and east. In advancing up any of the valleys, it is found at first comparatively broad and bounded by high bluffs of nearly horizontal sandstones; on approaching the central peaks, the valley becomes narrow, and the stream descends from a higher level 400 or 500 feet by cascades and falls: and beyond this the valley again widens somewhat with a more gentle slope to its head. The "fall-line" is found on all the radial streams, and is due to the local hardening of the sedimentary Laramie rocks by a central stock of coarsely crystalline diorite, which is irregularly oval in outline and about six miles wide at its greatest diameter. From their contact with this stock the Laramie strata, dipping gently outward, are hardened and metamorphosed to a distance of about a mile. The central portion of the diorite is cut by masses of a light-colored, finer-grained granitite.

"It is surprising," writes Dr. Wolff, "to see the similarity between this Tertiary diorite and granite and the Paleozoic masses of similar rock found exposed on the old eroded surfaces of the Atlantic states, as, for instance, on the northern shore of Boston. In both cases the same black patches are seen in the granite, referable here to enclosed dioritic fragments, and the same alternations of basic and acid rock in streaks or 'Schlieren' with parallel flow structure. * * * * The diorite stock as well as the adjacent Cretaceous rocks are cut by later vertical dikes of diorite-porphyrite and allied rocks; these dikes swarm in the contact zone, accompanied by horizontal and oblique sheets of similar rock. Mr. J. P. Iddings, who visited this place in 1891, finds that the vertical dikes, both in the stock and in all this part of the range, have a general radial arrangement, with the diorite mass as an approximate center, repeating a fact observed by him in a smaller diorite stock in the Yellowstone mountains. These long radial dikes extend outward even into the benches at the southern base of the range."

In the northern half of the range and its outlying buttes, the most prominent of the eruptive rocks, first collected by Dr. Wolff in 1883, is "found to be composed of feldspar (in part triclinic), augite and nepheline, with biotite, sodalite, magnetite, olivine, ægirine, etc., accessory; as an abyssal intrusive rock with the mineral combination nepheline, soda-lime feldspar, it filled a gap in the classification of Professor Rosenbusch, and was called by him 'theralite', as the first undoubted representative of this family."

In conclusion, the author speaks of these mountains as an easily accessible and magnificent field for further geologic and petrographic investigation. "From Livingston or adjoining stations on the Northern Pacific railroad it is an easy day's drive to the foot of the range; the canyons of the larger streams on the east side are easily accessible by horseback and at the entrance even by wagon, and it is possible to ride to the falls in the contact zone. The outlying theralite buttes can all be visited by wagon."

"*Geologie de l'ancienne Colombie, Bolivarienne, Venezuela, Nouvelle Grenada et Ecuador*" par HERMAN KARSTEN, Berlin, R. Friedlander & Son.

We distinguish in the region studied (Columbia, Venezuela and Ecuador) five definite geological periods of which the Jurassic is the oldest and has only recently been recognized in a locality in Columbia. The next period, however, the Lower Cretaceous outcrops in the mountains of the whole region and is characterized by a great variety of cepholapods. The presence in the lower strata which are specially marly, of Belemnites, Ptychoceras humboldtianus Krst., Ammonites nœggerathii Krst., Am. rothii Krst., Am. sawtapcinus d'Orb., Am. boussingaultii d'Orb., Hamites arboledæ Krst., might perhaps justify two subdivisions of this period.

The third series, the Upper Cretaceous, characterized by large deposits of limestones, sandstones and siliceous beds, may be recognized paleontologically by a great quantity of Rudistes which appear toward the east, and the Polythalamias, abundant in the centre and in the west.

The fourth period, the Tertiary, is characterized by the abundance of vertebrate remains and the presence of pebbles and thick conglomerates formed at the expense of the siliceux beds of the older periods. Also by the great extension of micaceous marls, trachytic cinders and *lapilli*.

The fifth period, the Quaternary, is represented by washings, gravels, beds of pebbles, and breccias with shells on the sea coast; the shells belong to species living at the present time.

Several cases of unconformity in the respective disposition of these five series, show that they also correspond to distinct epochs of elevation, and the geographical distribution of the Quaternary proves, in the most convincing way, even in the absence of a clear unconformity with the Tertiary, that these two periods were elevated at different times. The unconformities observed in the neighborhood of San Pablo in the lower Magdalena river probably mark this historical break.

The Quaternary has slight extension, some portions of the coast, somewhat elevated, belong to it. The Tertiary period is more developed; almost the whole of the immense plains of the Orinoco and doubtless large part of those of the Amazonas, belong to it; the highest summits of the actual continent, date from this time also.

The Cretaceous, in which investigations show several distinct epochs, formed elongated islands in the Tertiary sea, in lines toward the north-east. The eastern island was the present massive of Cumaria; another island of the eastern series represented the massive of Mérida, and the western island, surrounded to the south by an archipelago of small volcanic islands, was traversed by mountain chains, rich in veins, bearing gold and platinum.

It is quite remarkable that the steeper slopes of the Cretaceous region, which runs or extends itself in a circular arch toward the northeast, are turned to the massive of Guayana, whose rounded domes of granitic rocks rise from the Tertiary plains, as islands out of the ocean, as far as is known. On the contrary, the Tertiary strata, wherever they have been elevated in massives, either cover the slopes of the mountain chains or form *valleys* ("*vallée de fracture*") as the valleys of the Magdalena and Canea rivers, and the section of the strata looks to the valley.

The massive of Guayana appears to be the centre of the different mountains or Cordilleras belonging to Columbia, and upon which depends the direction of all of them. They rise to the west, in Columbia, and to the north in Venezuela, as the borders of a large circular crevasse, formed in the crust of the earth in the circumference of this primitive centre of elevation; crevasse which then was not recognizable by important massives in its total extension, but which marked the direction of the contemporaneous and future eruptions.

The elevating force which caused the formation of the crevasse around the granitic centre, appears to have worked from east to west, in the primitive times, and plutonic epoch; that is it began to the northeast, reached its highest development in the north, and diminished more and more to the south. On the contrary, the last elevation of importance, which took place during the Tertiary volcanic epoch, followed an opposite direction.

In the north the plutonic chains bordering the ocean reached their actual hight almost at the first elevation: at the end of the Cretaceous and Tertiary, they were only re-elevated; while in the south, they stood in part under the water, and only reached their actual form and hight at the end of the Tertiary, by the eruption of trachytic masses and lavas, which were very violent there, but became milder and milder toward the north.

Report on the geology of northeastern Alabama, and adjacent portions of Georgia and Tennessee. C. WILLARD HAYES. Bulletin No. 4, of the Geological Survey of Alabama. 8vo. pp. 86, Montgomery, 1892 One plate of topographic outlines, and one geological map.

This is a plain statement of the geological structure as made out in the field, over a critical area in the Appalachians, and covers all the Paleozoic from the Archæan to and including the lower Carboniferous, and some portion of the Coal Measures. The field work was done by Mr. Hayes as an assistant on the U. S. Geological survey, and was reported to the state survey in pursuance of a compact between the two surveys in a cooperative plan for the examination of a section embracing the lower end of Lookout mountain, near Gadsden. The report, however, and the accompanying report, embrace considerably more area, that mapped being about 87 miles east and west, and 72 miles north and south.

Mr. Hayes describes the remarkable fact, illustrated by the Rome thrust fault, that the lower rocks may be, and have been, faulted and raised and thrust bodily over strata of much later date in that portion of the Appalachians. In this case the Cambrian strata are found to lie upon the middle Carboniferous, and the distance through which the older strata have been moved westward, over the younger, by this thrust, is between four and five miles, and there is reason to believe that the Cambrian rocks once extended several miles further westward than they are at present found. The entire structure, stratigraphy, drainage, topography, are neatly and concisely described in this brief report. The map is based on the U. S. survey topographical sheets, and is a condensed expression of six of them.

Advance sheets from the eighteenth report of the Geological survey of Indiana. Paleontology. By S. A. MILLER. September, 1892. Indianapolis. Octavo, pp. 79, and 12 plates of fossils.

This pamphlet contains descriptions of seventy-six new fossil forms—Receptaculites, Cystites, crinoids, brachiopods, and cephalopods. They are from all points of the central area of the United States, mainly Indiana and Missouri, ranging from the Lower Silurian to the Carboniferous.

The Mapping of Missouri. ARTHUR WINSLOW. (Trans. Acad. Sci. St. Louis, Sept., 1892. pp. 57-99.) The author sketches the history of the successive attempts to make a map of Missouri, and illustrates, on reduced scales, some of the early maps, beginning with that of Ptolomæus, edited in Rome in 1508, and extending through the sixteenth and seventeenth centuries when little or no progress was made, to the eighteenth and nineteenth in which marked advance has been made in accuracy of mapping the region of the Mississippi valley in which Missouri shares a part.

The United States Coast and Geodetic survey began triangulation operations in Missouri in 1871, and has carried a network of triangles entirely across the state. The Mississippi river commission has accurately mapped the entire extent of the Mississippi in the limits of Missouri, and the Missouri river commission has delineated the Missouri valley in a similar manner, these organizations having done very accurate work, both in mensuration and topographical delineation.

The U. S. Geol. survey began, in 1884, to spread its inferior topographical work over the state of Missouri, and constructed 25 sheets, on a scale of about two miles to the inch. This work ceased in 1889.

The Missouri state survey is engaged in making topographical maps. Mr. Winslow enlarges the scale of the U. S. survey maps—reduces the vertical contour interval to 20 feet, adds township and county lines, represents railroads, etc., and produces sheets (now ten in all) of the size of $16\frac{3}{4}$ inches by $20\frac{3}{4}$ inches—a quadrilateral of fifteen seconds in extent in latitude and longitude, or from 228 to 240 square miles.

It is noteworthy that for the purposes of the state geological survey in this instance, the topographical sheets of the U. S. Geological survey are rejected as unsuited and inaccurate, and the state survey proceeds to re-map *the same areas* from data supplied by the United States Coast and Geodetic survey, or by the river commissions.

The rounding of sandstone grains of the Trias, as bearing on the divisions of the Bunter. T. MELLARD READE, F. G. S., (Proc. Liverpool Geol. Soc., 1891-2). The author arrives at the conclusion, after comparisons of Bunter sandstones from various localities, that the roundness of the quartz grains, greater or less at certain localities, and the occurrence of pebbly strata, neither one, is any reliable indication of the horizon in which they occur. "The Bunter sandstones are a great group in which, form whatever cause, there has been a large impregnation of ferric oxide and other impurities which have in a majority of cases interfered with the deposition of secondary silica. The grains have also been laid down in turbulent conditions of current, evincing long travel of an oscillatory or tidal character." The author does not attempt to assign a cause either for the "turbulent conditions," or the presence of large amounts of ferric oxide. Could not marine volcanoes have produced both, cotemporaneously with the accumulation of the sands? Again, in case of copious deposition of secondary silica, as in the silica embracing the pebbles of the "Pebble beds," which seems to have alternated, geographically as well as stratigraphically with the copious formation of ferric oxide, could not the same cause have operated to precipitate silica from the waters of the Triassic ocean and thus embrace the accumulating pebbles or quartz grains? It is a significant fact that these two elements, "secondary" silica and ferric oxide, are frequently associated in this way.

The Iron Deposits of Arkansas R. A. F. PENROSE. Annual report for 1892 of the Geological Survey of Arkansas, Vol. I, Octavo, pp. 153. Little Robk, 1892.

The report states that prior to 1860 two small bloomaries for iron, one in the northeastern and the other in the northwestern portions of the state, were in operation, but that since they ceased no iron has been mined, nor made in the state. This is owing to the poor quality of the ore and to the easy introduction of iron made in other parts of the United States, particularly in Missouri, since the construction of railroads.

Iron ore of rather low grade is found in the state distributed from the Lower Silurian to the Recent formations, except in the Cretaceous, and geographically it is spread over most of the state. The ore at Magnet cove is not in sufficient quantity to be of value for iron manufacture. Most of these deposits are limonite. There is some spathic ore from the Carboniferous shales and Tertiary clays and sands, and limited quantities of magnetic ore. The last occurs in a residual clay derived from the decay of crystalline rock in Magnet cove, and is known as Arkansas lodestone. This is the only ore in the state containing an appreciable amount of titanium. Generally all the Arkansas ores are non-bessemer.

The ores in the northeastern part of the state are probably in the Lower Silurian but their exact stratigraphic position is not known. The evidence seems to indicate that they are below the Calciferous. The rocks dip under the saccharoidal sandstone, and the Izard and St. Clair limestones which represent the upper members of the Lower Silurian system in the Batesville manganese region, to the south of the iron region.

The ores in the northwestern part of the state are probably on the same geological horizon, or perhaps somewhat in the Boone chert of the Lower Carboniferous.

The ores of the Arkansas valley are in the Carboniferous and Lower Carboniferous.

The iron ores of the Ouchita mountains occur in a series of novaculytes, siliceous shales, quartzytes and sandstones, though most of the deposits are immediately associated with the novaculyte and the siliceous shales. These strata are regarded Lower Silurian. They have furnished a few graptolites which Dr. Gurley regards as of Trenton age, but "the exact stratigraphic relations of some of the graptolite shales to the novaculytes are as yet uncertain." This is the same novaculyte series that contains the manganese deposits, and has a thickness, sometimes, of 450 feet, in other places thinning out altogether. The ore, the eruptive associations, the novaculyte, the slates, the titanium in the Magnet cove magnetite, the non-fossiliferous nature of the strata and the manner of occurrence of these deposits furnish many parallels with the ores of the Mesabi iron range in Minnesota, and strongly suggest a probability of equivalence of age.

The iron ores of southern Arkansas are in the Eocene of the Tertiary, and mostly below the Claiborne horizon of that series. These are limonites and small quantities of carbonates. Of these the author enters into a careful consideration of their origin. He traces them through the following stages.

(1) The derivation of the iron from the decay of the rocks in the drainage area of the sea which in Tertiary times occupied the position of the present gulf of Mexico.

(2) The solution and transportation of the iron in the form of soluble organic and inorganic salts.

(3) The precipitation of the iron as oxide or carbonate in lagoons or bogs along the coast.

(4) The segregation, as carbonate (clay ironstone) of the iron precipitated in the above forms.

(5) The conversion of the carbonate into the hydrous sesquioxide of iron (limonite) after the lagoons on the coast of the Tertiary sea had been elevated into a land area.

Although the iron ores of the state are at present commercially valueless, this is a valuable report. It sets at rest the ardent expectations of some prospectors and deprives them of their wealth, so far as it could consist in imaginary stores of iron ore, but it will be found to conduce greatly to the wealth of the people at large. It will forestall future ill-directed expensive exploration throughout the regions described, and will allow the citizen to prosecute in quiet the peaceful pursuit of such industries as the state actually possesses.

Studies of Muir Glacier, Alaska. HARRY FIELDING REID (Nat. Geog. Mag. IV, Mch. 21, 1892). Some of Mr. Reid's conclusions disagree largely with previous studies upon the same glacier. He finds the greatest advance to have been seven feet two inches daily, and the smallest four inches. Professor Wright's greatest advance, as measured in 1886, was 72 ft. (*Ice Age in N. A.* p. 50); however, if we assume both measurements as correct, a change of climatic conditions may account for the very great difference. The erosion is estimated at three quarters of an inch per annum.

Mr. Cushing, the geologist of the expedition, found the exposed rocks to consist of limestone, argillite, quartz-diorite and diorite; and Dr. Williams' microscopic examinations revealed several diorites, porphyry, porphyrites, gabbro (troctolite not from the glacier) and diabase. Dr. Herrick contributes a "microscopical examination of wood from the buried forest," pp. 75 78; Mr. Rowlee, a list of plants and finally Mr. Reid, meteorological and magnetic observations and suggestions to future observers.

Gibraltar—par PAUL CHOFFAT. (Bull. Soc. Géol. France.) This interesting contribution is chiefly a criticism of the report on the geology of Gibraltar made some time ago by Ramsay and Geikie, who, according to M. Choffat, were unable, on account of artificial obstruction, to view the best exposed portions of the rock, which are now inaccessible. These gentlemen obtained but a few specimens of a single species of Rhynchonella, which was determined by Messrs. Etheridge and Davidson to be very near *R. concinna* Sow., thereby placing the rock in the same horizon as the Great Oölite and Cornbrash of England.

M. Choffat then alludes to the excellent report upon this celebrated rock by Smith, made many years ago, in which these remains are described as *R. tetrædra* Sow., Lias. M. Choffat has been able to examine this species and also those collected by Ramsay and Geikie and finds they are identical. As this species (*tetrædra*) occurs in the Alpine Lias, and as the author has lately discovered the same in Portugal he sees no reason for changing the age, as proposed by the two English observers. He therefore contends that the age (Lias) proposed by Smith is the proper one.

On Nepheline rocks in Brazil, Part II. ORVILLE A. DERBY. (Quart. Jour. Geol. Soc. May, 1891.) In this paper the author comes to the conclusion that the Tingua peak, in the midst of an area of gneiss, composed as it is of orthoclase-nepheline rocks some of which are fragmental tuffs though hardly distinguishable from phonolite flows, is a *parasitic* or *superimposed* mountain, according to the nomenclature of Von Richthofan. This is but one of a number of localities in which the same features and the same rocks occur. Its age is unknown, but later sedimentary rocks containing similar eruptive rocks are near, and in the vicinity are Carboniferous fossils. It would appear therefore that the peak may be a remnant of a volcanic cone left after the denudation of Carboniferous rocks in which it may originally have been embraced. It is comparable to the basic volcanic tuffs that form a marked feature of the Keewatin, of the Archæan of the "Northwest," in the United States.

Classification of the Cephalopoda. In the May number of the *Proc Geol. Assn.* (London, 1892, XII) comparison tables were given of the various systems of classification. In the July number another list is given, designed to replace the former. Table I is Hyatt's classification 1867-83; Tab. II is Fischer's, 1882-3; Tab. III, Zittel's, 1884; Tab. IV. Bather's, 1888; Tab. V, Steinmann's, 1890. Bather's is the most remarkable mainly on account of its brevity, here showing Lipoprotoconchia, sub-ord. Nautiloidea. Sosiprotoconchia, sub-ord. Ammonoidea, sub-ord. Coleoidea (Osteophora, Chondrophora).

Penfieldite, a new species. (Am. J. Sci. XLIV, 261.) Associated with anglesite and laurionite from Laurion, Greece, Dr. Geuth has discovered a new lead oxy-choride of the composition $PbO. 2 PbCl_2$ (Cl.—18.21, Pb—79.73 O—2.06). Hexagonal, white, vitreous to greasy. Named after Prof. S. L. Penfield.

Handbuch der Mineralogie. The sixth part of this excellent work by Dr. Hintze has just been issued. It treats principally of the serpentines sodalite nephelite, kaolinite and associated minerals.

Protolenus, a new Genus of trilobites. G. F. MATTHEW. (Bulletin X, Natural History Society of New Brunswick, Sept., 1892.

The new genus of which two species are described, *Protolenus elegans* and *P. paradoxides*, occurs in the beds of Band *b*, division 1, of the St. John group, at Hanford brook, New Brunswick.

The Glacial Succession in Europe. JAMES GEIKIE. (Trans. Roy. Soc. Edinburgh, Vol. XXXVII, Part 1, pp. 127-150.) 4to, with a map. This is a review of the evidence in Europe for the idea of three or more glacial epochs in Pleistocene time, and he concludes that at least four such epochs of cold can be established. He goes further, and extends alternating seasons of cold and warmth into Pliocene time, thus making five glacial and four interglacial epochs.

CORRESPONDENCE.

ON THE KEOKUK GROUP.—The August No. of the GEOLOGIST contained an interesting paper on this subject by C. S. Beachler. In giving the literature he has overlooked a paper by the writer published in the American Journal of Science for October, 1890, in which the conclusions were practically identical with those now brought out by Mr. Beachler. In this paper a detailed section was given of the beds at Keokuk, and a study made of the fossil forms in which it was shown that the Crawfordsville crinoidal bed represents the thin sandy stratum sometimes found at Keokuk above the geode bed, and represented by No. 13 of the section. This conclusion had been announced previously in a paper before the Iowa Academy of Science (Mar. 10, 1890).* Mr. Beachler has arrived at the same results independently from a study of the Indiana area.

These studies tend to a separation of beds hitherto considered identical though much additional work is needed to set at rest obvious questions.

The disposition of the chert or transition bed below and the Magnesian or Warsaw above is still an open question, though recent writers seem to favor Owen and Hall in including them with the Keokuk. The evidence seems to sustain the following arrangement, here given tentatively:

		KEOKUK.	INDIANA.
KEOKUK.	UPPER KEOKUK.	Magnesian or Warsaw beds. - -	Spurgeon Hill beds.
		Blue Sandy bed. - 6 inches—seldom seen. (No. 13 of my Section.)	Crawfordsville beds.
		Geode bed. - -	Indian Creek shale. Bono beds.
	LOWER KEOKUK.	Limestone bed. - -	Walnut Fork beds.
		Chert bed. - -	New Ross beds.

This follows very closely Owen's division, made in 1852. In a paper on the Mississippian Section (Lower Carboniferous) before the G. S. A., C. R. Keyes has given a brief descri tion of the Keokuk group, in which he ignores the work of previous observers, and gives but an imperfect exposition of this important group of rocks.

Evanston, Ill. C. H. GORDON.

W. M. HARVEY.—Another quiet and earnest worker in the field has been called to rest. Mr. W. M. Harvey, of Glen Rose, Texas, was buried on the 12th inst. To most of the readers of this journal his name was unknown. He belonged to none of the scientific societies, and held no scientific position, yet he lived a life devoted to nature, and through his explorations, made in the intervals of leisure he was able to take from his occupation as a house carpenter, discovered important material, now in the hands of Prof. L. F. Ward, of the U. S. Geological Survey, and Prof. E. D. Cope, of most signal value in completing the determination of the great lower Cretaceous system of this country. Through his patience as a collector, many important results were secured, in the vicinity of Glen Rose, including a locality where marine mollusca of the Trinity formation, as figured in the Arkansas reports, were associated with the Potomac flora of the north Atlantic states, and above all, with the first determinable fossil vertebrates from those beds, including crocodile and fish remains. This discovery is important because, with the three fold evidence it affords, the age of the lowest fossil bearing beds of the Comanche series can now be fixed with certainty. Professor

*Proc. I. A. S. 1887-9, p. 100.

Harvey was a native of Cincinnati, and acquired his love of fossils from association with the old school of paleontologists who there enthused all who met them with a love of science. He migrated to Texas for health and fortune. It was the writer's good fortune in 1889 to discover him in his cottage filled with a rare local collection of the beautiful fossils of the adjacent country, and, again, in October, last year, to take to his home Prof. Lester F. Ward, under whose direction he collected a most abundant and important flora of the Potomac (Trinity) beds, which has been studied by Prof. Fontaine, and is now ready for publication. Mr. Harvey was one of many local geologists whom the writer has met in out-of-the-way places, working for the love of science, enduring the opprobrium of scoffing environment, but who, when the final award of honor will be given, shall find equal credit with those who, surrounded by every opportunity and luxury, have often accomplished less.

R. T. HILL.

PERSONAL AND SCIENTIFIC NEWS.

NEW DISCOVERIES AT MENTONE, *France*. The discovery of three skeletons in this celebrated cave was made last February; they were unearthed at a depth of about five feet, which is about 25 feet below the original floor of 1872. The remains indicate a man of perhaps more that seven feet in hight; perforated teeth, shells, etc., were also unearthed. Mr. Vaughan Jennings, F. G. S., who visited the spot in March, suggests (Nat. Sci. I, 272) that from a study of the implements found with the remains, they may belong to the neolithic age, but the skulls indicate an even more ancient type; however, the author concludes that the fact that similar perforated teeth, etc., have been found in the Dordogne cave of the same age as the classic drawings on bone, of the mammoth and reindeer, strengthens very much, the argument for the palaeolithic age of the Mêntone man.

MESOZOIC FOSSILS FROM CENTRAL HIMALAYA. (Nat. Sci. I, 447.) Fossils from India recently examined in Vienna are found to conform in a marvelous degree with eastern Alpine species. Dr. Diener has formed an exploring party to visit the Himalayas for the express purpose of studying the fauna thereof with a view to comparison with the Austrian-Alps fauna.

THE GREENLAND EXPLORING EXPEDITION: The relief expedition sent out last summer has returned, bringing with it all the members of the first expedition, with the sad exception of the young geologist, John Verhoeff, who was lost while out alone on a geological expedition. To quote Mr. Peary, "I have traced the northern limit of the interior ice-cap of Greenland; I have settled in my own mind the northern limit of the mainland of

Greenland, demonstrated the existence of enormous glaciers in all the northern fiords; I have completed surveys of Davis bay, Inglefield gulf and Whale sound, and finally I have had exceptional facilities for studying that most unique tribe of about 250 persons, the arctic highlanders."

We shall await with great interest Mr. Peary's reports upon these obscure subjects. The Academy of Natural Sciences of Phila., has the credit of giving support to this most successful expedition.

THE MICHIGAN MINING SCHOOL, at Houghton, Mich., has recently been endorsed and commended by a committee appointed by the Superintendent of Instruction, consisting of D. A. Hammond, Perry F. Powers and S. E. Whitney. They made two visits of inspection, and report: "The Michigan Mining School, we may say in closing, has come to stay; because it has demonstrated its fitness to live. Whatever may have been its weakness in the past, it is now doing valuable work. It is well equipped, has an able faculty, and a demand upon it greater than it can now supply. We see no reason why it should not be a very valuable auxiliary in the future development of the mining resources of the state."

CHANGES IN THE DEPARTMENT OF GEOLOGY AT THE KANSAS STATE UNIVERSITY. Prof. S. W. Williston, the former incumbent of the chair of geology, retains paleontology and vertebrate anatomy. Mineralogy and physical geology have been created a new chair to which Prof. Erasmus Haworth, late of Oskaloosa, Iowa, has been appointed as associate professor.

MR. J. F. WHITEAVES COMMUNICATES to the *Canadian Record of Science* for October, a description of a new genus and species of phyllocarid Crustacea from the middle Cambrian of mount Stephen, B. C. Three genera of Phyllocarida are known from the Cambrian rocks of Europe and America. The new genus, *Anomalocaris*, now described by Whiteaves, adds a fourth. *Anomalocaris* differs conspicuously from the other genera in the characteristics of the abdominal appendages and in the number and disposition of the caudal spines. The type specimen is named *A. canadensis*.

DR. FLOWER'S RECENT LITTLE BOOK, "The Horse," (New York, D. Appleton and Company,) though not primarily designed for specialists, will be found a very convenient aid to advanced students, not only in biology but in geology as well, since it presents a most excellent summary of the present state of scientific knowledge concerning an animal that figures prominently in both of these sciences.

DR. OTOMAR NOVAK WHO WAS CONTINUING THE RESEARCHES of Barrande into the Silurian faunas of Bohemia while filling the chair of geology at the University of Prague, died on July 29th. He was only 42 years of age.

FIG. 1.

FIG. 2.

MICROSCOPIC SECTIONS OF SO-CALLED CANNEL COAL.

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A PRELIMINARY EXAMINATION OF SO-CALLED CANNEL COAL FROM THE KOOTANIE OF BRITISH COLUMBIA.

By D. P. Penhallow, F. R. S. C., F. R. M. S., McGill College, Montreal.

Plate X.

During the past year a number of specimens of a coaly mineral having the general properties of a cannel coal, and locally recognized as such, were obtained from the Kootanie and Lower Cretaceous formations of British Columbia. Their peculiar physical constitution, and the great difficulty of ascertaining association with any of the materials ordinarily known to contribute to coal formation, made their examination a matter of more than ordinary interest. The specimens at first placed in my hands, consisted of a slide by Mr. Weston of the Geological Survey, together with a small fragment taken from a characteristic hand specimen. They were submitted to me by Sir Wm. Dawson, who had received them from Dr. George Dawson of the Geological Survey. A preliminary inspection satisfied me that a more extended examination of the original material was desirable. Dr. Selwyn, of the Geological Survey, kindly supplied me with five characteristic hand specimens from as many different seams, some of them widely separated. These were submitted to a critical examination, and from some of them, a number of fresh slides were prepared.

So far as their general characteristics are concerned, these coals are all of the same nature, differing chiefly in degree of consolidation under the influence of pressure. In all the more compact specimens the fracture is conchoidal and lustrous; a few show a coarse lamination while others do not. All agree in being made up of similar rod-like bodies which are more or less closely compressed. In one case the rods were loosely piled in a promiscuous manner, in such a way as to exhibit their form and size very perfectly, being held together, apparently, by a partial fusion with one another, or by a cementing substance of a similar nature. In the most compact forms, it could be readily ascertained that the rods constituted the entire substance of the coal, their transverse and longitudinal fractures being sufficiently conchoidal and lustrous to distinguish them from one another. The rods are round and straight, and closely resemble, in some of the less compact specimens, rods of amber of dark color. The least diameter found was 0.5 mm. From that they range upwards to 2. mm., which, however, is not very common. Their length appears to lie between 5 mm. and 2.5 cm. One specimen was characterized by a decided flakiness, the flakes being closely compressed and apparently composed of finer laminæ of a substance similar to that constituting the rods.

Several sections were taken from the different hand specimens and prepared for microscopical examination.

Section 2136 was prepared by Mr. Weston of the Geological Survey, from one of the least compact of the hand specimens. It shows the rods to be cut variously, but chiefly transverse and longitudinal. Lines of flow none; tissue or cell structure none. Granulations common and often disposed so as to form zones surrounding hyaline areas. Granules round or oblong and often spore-like, 1.9 μ in diameter. Color, reddish amber. Irregular lines of fracture often penetrate the rods at right angles for one-fourth their diameter; they usually show as shrinkage clefts or air tubes.

A conspicuous feature of the rods is the presence in their interior of tubular, often branching, openings which are strongly suggestive of vegetable growth, and at first are apt to lead to the supposition that they are fungous mycelia. On account of their peculiar form, it may be well to refer to them as myceloid tubes or ramuli. They may be roughly classed as of two kinds—large and small.

The large tubes were found to be cut in all ways, precisely as long, tubular cells loosely and sinuously disposed would be, so that there were longitudinal and transverse, as well as oblique sections of them. Longitudinally they show an apparent cell wall and prominent central cavity. They are more or less vermicular and simple or irregularly branching. The cavity is often filled with a poorly defined granular substance, and they sometimes contain air.

In transverse section the apparent wall appears prominently, and shows as what seems to be a rather thick wall with an outer and dark, limiting membrane. The tubes are usually about 39 μ broad, and the wall 14 μ thick.

The small myceloid ramuli are freely branching and somewhat interlacing, and in many cases are filled with air. It is very common to find them occupying large areas of the rods, while less frequently they assume the form of stellate groups closely resemblings tufts of *Rivularia*. These groups are commonly 109 μ broad The separate tubes measure from 1.9 μ to 3.8 μ and even 15 μ in diameter. In the smaller forms where the radial disposition is most pronounced, these ramuli commonly terminate in sub-spherical pockets.

The substance lying between and apparently cementing the rods together, consists chiefly of a fine granular matter—the granules being very angular—which seems to have been derived from the same material as the rods through some pulverizing action.

Section 1 was prepared at the Redpath Museum, as were all the following sections. In this the rods show frequent round air cavities measuring from 9.6 μ to 105.6 μ in diameter. Small laminæ and angular fragments fill the spaces between the rods, apparently consisting of the same material. The rods themselves are wholly structureless and otherwise as in the preceding section.

In section 2 the rods are cut longitudinally and transversely. Lines of flow and evidence of structure wholly wanting. The fine, myceloid ramuli are abundant and often contain large quantities of air. The large ramuli are not very abundant, but when present usually contain air. The interstitial substance forms a spongy cement—being traversed by numerous round openings consisting of minute, angular fragments of amber-like material imbedded in an amorphous substance of somewhat granular character and possibly derived from cellular structure. The whole forms a cementing substance which unites the amber-like rods.

Section 3 is that of a flake taken from hand specimen number 5. It is composed of a spongy mass, possibly the residue of cellular structure, in which are embedded small fragments of amber-like substance of angular form, the whole as in the interstitial substance of number 2.

Section 4 was obtained from a single rod or filament 1 cm. long by 1.25 mm. wide. Structure none. Round cavities similar to air bubbles, frequent, but not so conspicuous as in many other cases.

The details thus outlined sufficiently express the characteristics of all the other sections examined, and the general results of the examination make certain facts prominent.

1. The total absence of structure.

2. The presence of tubular ramuli of diverse dimensions.

3. The presence of rounded cavities.

4. The presence in large quantity, of angular fragments of material of the same nature as the rods.

5. The presence of an amorphous substance together with the last, either occurring as distinct flakes, or acting as a cement to unite the rod.

It is desirable that these facts be considered somewhat in detail.

The complete absence of structure throughout the numerous rods submitted to examination, is significant. Out of several hundred rods there was only one instance of an appearance which was at all suggestive of derivation from structure. In this case, a very limited area was occupied by a series of rather closely arranged plates running transversely to the axis of the rod, but these are, I think, capable of reference without serious question, to the action of internal shrinkage. (Fig. 2.) Had normal structure at any time constituted a part of these rods, it is quite likely that out of one or two hundred, some evidence of this fact would have appeared. The total absence of such evidence lends strength to the view that the rods must have been derived from material originally structureless and, practically, of the same nature as now found.

The presence of spore-like granulations is a feature more or less common to all organic structure which has passed into a fossil state, and is incident to the more or less complete breaking up of the original organic matter with the elimination of the elements of water. When such changes occur, the modified parts acquire a darker color which eventually become black, assume a granular form and dispose themselves in accordance with the particular nature of the molecular changes in the material as a whole. This has elsewhere* been shown to produce very peculiar effects, as in modification of the structure of *Nematophyton*. In this it is possible to find a satisfactory explanation of the distribution of granules about the surfaces of air tubes or internal fissures in such a way as to produce the appearance of a cell wall.

The presence of tubular ramuli is a condition which, without critical examination, might seem to justify the opinion that mycelia had penetrated the body and become permanently preserved. This necessitates the supposition that (a) the material of the rods was once soft and that when in that condition it had flowed over and engulfed the associated fungi, or (b) that while plastic, it possessed nutritive properties and was readily penetrated by fungi. The total absence of lines of flow offers serious opposition to the first hypothesis, and indicates that the rods were, from the first, of the form and general character now found. The second hypothesis is probably not admissible for reasons which will appear later, although it is undoubtedly true that the rods were originally composed of a soft and even viscous substance.

It is furthermore found that the ramuli are not septate, but form continuous simple or branching tubes; their branching is irregular and not determined with that uniformity which is consistent with the growth of organic structure; the tubes are irregular and often contain side pockets such as no vegetable structure is known to have, but such as might readily be formed under certain conditions of contraction in the surrounding mass. Also, the remarkable disposition of these tubes is wholly inconsistent with their character as possible vegetable structures.

Precisely similar tubes may be formed under certain conditions, in any plastic material. It is a matter of common experience in the preparation of glycerine jelly mounts, that if a somewhat excessive pressure be applied to the central area of the cover glass, the latter will be slightly bent down below the line of the margin. Upon removal of the pressure after the jelly has hardened, the

*Trans. Royal Soc. Can. VIII. IV. 24-25 AMERICAN GEOLOGIST, IX. p. 369.

cover glass springs back to its normal position and in so doing tends to draw away from the jelly immediately below. The necessary consequence of this is the formation of a cavity which, owing to the peculiar consistency of the jelly, will assume the form of a series of irregularly branching ramuli often dispersed in a stellate manner. The figures and tubes thus formed are in all essential respects the exact counterpart of the ramuli found in the rods of cannel coal now under consideration, and I think we may safely infer that the latter arise from the same general cause as the former. This would make them the result of internal shrinkage caused by the gradual elimination of a volatile element, but as the loss of such a volatile constituent must always take place first at the surface, there would necessarily be formed an external layer of greater resistance which would tend to preserve the original form and promote a shrinkage through the central mass towards the firmer bounding layer. This view is also justified by the known occurrence of similar shrinkage cracks and pockets in amber and other forms of fossil resin.

The material occupying the spaces between the rods and apparently cementing them together, consists of an amorphous and irregularly granular mass full of rounded holes, thereby giving it a spongy character. Within this matrix are imbedded numerous small, angular or rounded—sometimes laminæ—fragments of material which, from its general aspects, appears to be the same as the rods, and in all probability is the material of rods which were broken up in various ways. The presence of such fragments and the curious way in which the rods are massed in thick seams, together with the absence of other material, would seem to indicate the agency of water. The source of the amorphous substance is not so clear. It has no apparent relationship with the rods and fragments, nor does it anywhere present any structural aspects, so that we are left wholly in doubt as to its possible nature. A hypothetical view might regard it as the debris of vegetable structure, but it does not appear so carbonaceous as material from such a source should be.

These considerations render it fairly clear that the origin of these coals must be sought in some other direction than modified vegetable structure. From their character as determined by microscopical examination, from their fracture and color in transmitted light, as well as from their combustible nature, we can only conclude that they represent some form of fossil resin. The possibility of their derivation from resin was first suggested by Dr. G. M. Dawson in his first letter transmitting the specimens. But certain difficulties seem to stand in the way of this hypothesis. Among these is the absence of any lines of flow. We may, however, conceive the resin to have been solidified in the resin passages of the tree, and this is certainly implied by the form and size of the rods as now found.

Again, the enormous volume of these rods, sufficient to produce thick and extensive coal beds, would almost seem to be incompatible with their origin in the way suggested above, unless we suppose (a) that the resin bearing trees of that period were enormously abundant—far exceeding anything known in modern vegetation, and possibly of a species which has ceased to exist, or (b) that the trees produced resin in such enormous quantity that rapid and great accumulations were possible.

The complete absence of any definite structure associated with the specimens, still further complicates the problem, though it is quite possible that the plant remains found in the surrounding strata may throw important light upon the subject, when opportunity offers to systematically collect and study them. In the present state of our information, three possibilities suggest themselves. (1) The resin was produced wholly in the bark. Upon decay of the trees the bark separated from the wood, the two floated independently and may have eventually reached the same or different places of deposit. The free bark while floating suffered sufficient disintegration to liberate the contained resin, which was carried to a separate place of deposit. This hypothesis gains no support from modern vegetation, and is doubtless one which will fail to satisfactorily account for the great accumulations found. (2) The occurrence of the resin in the wood or in both wood and bark, the structure of which decayed sufficiently to liberate it after being hardened. In such case we might reasonably expect to find some remnant of the woody structure associated with the rods. Their purity, however, indicates a complete separation from the structure in which they had their origin, and, moreover, such separation must have taken place with great facility. Modern examples lend no support to this view. (3) The resin tubes may have been produced in layers in such a way as to promote a rapid and complete breaking up of the organic structure in drying or decay, with consequent liberation of the indurated resin. The subsequent action of water would tend to separate the two completely, and thus establish the purity of the resin as now found. The only possibility of obtaining any support for this theory from modern vegetation, came to us at the close of my examination of these coals, in a report that certain spruce and tamarack trees now growing in the Kootanie district do produce resin in large quantity and in such a way as to determine their speedy breaking up when subjected to desiccation or to maceration, and that from them might be derived data which would have an important bearing upon the nature of these coals. As it was important that evidence of so promising a nature should be examined, I asked Mr. D. A. Stewart, of Winnipeg, an engineer in the employ of the Canadian Pacific railway, if it would be possible to procure for us, specimens of the trees in question. This he very kindly consented to do, and we have since been placed under obligations to both Mr. Stewart and other officers of the Canadian Pacific, by the receipt of four fine specimens measuring about two and one-half feet long, and with diameters of upwards of a foot. Since then all of the specimens have been carefully examined and with wholly negative results. The details of this examination will appear later. It is sufficient for our present purpose to point out that the last hypothesis advanced to account for the origin of these coals receives no support from modern vegetation, and we can only hope, therefore, that in future examinations of these deposits, associated plant remains may be found which will throw light upon a now very obscure problem.

A chemical examination of these coals has been made by Mr. G. C. Hoffmann, of the Geological Survey of Canada,* but as his results bear only upon their fuel value, they throw no light upon their origin. At my request, Dr. Harrington, of McGill College, has kindly undertaken to determine the soluble constituents in order to bring them into comparison with certain fossil resins from Cedar Lake, which he had already examined.† The Cedar Lake resins show 21.01% soluble in absolute alcohol, and 24.84% soluble in ether. The cannel coals in question show only 4.6% soluble in chloroform, and 3.17% soluble in ether, the solution in each case being strongly fluorescent. It is, therefore,

*Rept. Geol. Surv. Can. IV, 7 R.

†Amer. Jnl. Sci. XLII, 332.

obvious that no direct comparison can be made, but while these results fail to show relationship between the amber or fossil resin and the cannel coal, they do not enable us to say that the latter did not have its origin in vegetable structure. It is quite possible that the greater degree of insolubility of the coal may be the result of a greater degree of alteration.

EXPLANATION OF THE FIGURES. PLATE X.

1. Coal showing rods in longitudinal section, together with granular matter lying between, × 6.
2. Filament of coal in longitudinal section showing a small area occupied by transverse shrinkage cracks, × 70.

CONDITIONS OF ACCUMULATION OF DRUMLINS.*

By WARREN UPHAM, Somerville, Mass.

CONTENTS.

STATEMENT OF THE PROBLEM.

Definition and Varieties of Drumlins.—The drift hills called drumlins consist, at least superficially and in most cases throughout their entire mass, of till or boulder-clay, being unstratified clay, sand, gravel, and boulders, mingled indiscriminately together, which therefore must be attributed to deposition by ice without modification by the assorting and stratifying action of currents of water. They have usually an oval form, with smoothly

*This paper, in preliminary outlines, was presented before the Geological Society of America, Aug. 16, 1892, at the meeting in Rochester, N. Y., as noted in the October GEOLOGIST (p. 218). Further study has since led to the opinions given here, that the englacial drift of which, under this view, the drumlins appear to have been chiefly formed, had become superglacial by ablation and was afterward enclosed as a stratum within the ice-sheet, being thence amassed in these hills; and that, according to such explanation of the origin of the drumlins and their comparison with the terminal moraines, the Ice age may probably have comprised only a single glacial epoch.

rounded top and steep slopes, especially at the sides, from which features Prof. C. H. Hitchcock in 1876 named them *lenticular hills*, the first distinctive term applied to these drift accumulations in this country. Subsequently the name *drumlins*, used by M. H. Close ten years earlier for similar hills and ridges of till in Ireland, has come also into common use here.

Oval or elliptical forms of drumlins prevail, with rare exceptions, in New Hampshire, Massachusetts, and Connecticut. In some other districts, as in central New York, these hills vary from the oval type to prolonged ridges, running nearly straight several miles; and in eastern Wisconsin, as described by Chamberlin, they are prevailingly circular and dome-shaped on some areas, being therefore called *mammillary hills*, while in other localities they occur mainly as long parallel ridges. Wherever drumlins are found, their longer axes trend in parallelism with the courses of the glacial striæ and transportation of boulders, that is, with the current of the ice-sheet. Glacialists are agreed that this relationship and the very regular and smooth contour of the drumlins resulted from the moulding action of the overriding ice, to which masses thus elongated opposed the least resistance.

In the areas of their greatest development the drumlins range in hight from 25 or 50 feet up to 200 feet or rarely more, and proportionately in length from an eighth of a mile to one mile, or, in tracts where they become long ridges, two to three miles or more. The slopes of their ends are gentle or moderately steep, having from 5 to 20 feet of ascent in a distance of a hundred feet; but the steeper ascent of their sides varies usually from 15 to 30 feet in the same distance. Instead of amassing the till in such prominent accumulations, we should expect that the ice-sheet would tend constantly to wear away the hill tops and leave thick deposits of subglacial drift only in depressions of the country and on low or nearly level land.

That the drumlins are commonly till or boulder-clay from crest to base is shown by sections of wells and other excavations, and on the coast by wave erosion, as in Boston harbor and its vicinity, where a third or half of a drumlin in numerous instances has been washed away, leaving sea cliffs of till from 20 to 100 feet high. Frequently, however, drumlins rest on moderate elevations of the bed rocks, which outcrop on portions of the lower slopes to a hight of perhaps 50 or 100 feet, forming a pedestal capped by the rounded mass of till for the upper half of the hill.

Again, lenticular slopes of till, having the same smoothly flowing outlines as the drumlins, are sometimes accumulated on the lee side of hills of rock; the hill and the detritus sheltered behind it being known as "crag and tail." A large number of such slopes were mapped by the writer in 1878 in New Hampshire, besides about half as many similar slopes of till lying upon the northern sides of rock hills, where they were most fully exposed to the ice-current. The knobs of rock in each case may be said to have combed the drift from the ice by which it was being borne forward. More rarely the slopes were gathered upon both north and south sides alike, blending together and assuming the form of a drumlin, but having outcrops of rock at the top. In Massachusetts, however, though almost equally a region of plentiful rock hills, Mr. George H. Barton, in mapping the drumlins, finds very few of these till slopes.

Most instructive variations from the usual constitution of the drumlins are presented where anticlinally stratified beds of gravel, sand, and clay or fine silt, form their inner part, reaching in a dome-shaped accumulation from the base upward to comprise sometimes the greater part of the section, with a deposit of till, which may be from a few feet to 25 feet or more in thickness, spread over these beds so as to form the entire surface. Among many sections of drumlins observed by me in New England, the only examples of this structure are Third and Fourth Cliffs, partially eroded drumlins in Scituate, Mass., on the shore of Massachusetts bay.* These rounded, low hills, rising respectively about 70 and 60 feet above the sea, consist of till upon their whole surface and to a depth that varies from 15 to 25 feet and more, but below include beds of modified drift that attain in Third Cliff a thickness of at least 30 to 40 feet, reaching to the boulder-strewn shore, and in Fourth Cliff a thickness of 10 to 20 feet, being seen there to be underlain by till and to be also in part interbedded with it.

In Madison, Wisconsin, and its vicinity, drumlins having thus an anticlinal nucleus of modified drift and surface of till are more frequent, as I am informed by Prof. T. C. Chamberlin and

*Proceedings of the Boston Society of Natural History, Vol. XXIV, pp. 228-242, with map and sections; April 17, 1889.

Mr. I. M. Buell. The hill on which the state capitol is built belongs to this class, as shown by the section of its artesian well.* Its hight is about 80 feet above the adjoining lakes, and the section passes through till for the first 8 feet, and through sand and gravel, enclosing occasional boulders, for the next 72 feet.

Geographic Distribution.—Generally throughout drift-bearing areas the till, excepting where it is accumulated in the hills and knolls of the terminal moraines, has a comparatively low and level or moderately undulating surface. But on certain tracts a large part of the till is exceptionally amassed in the drumlins, which stand up very conspicuously as high hills, sometimes occurring plentifully with irregular arrangement in groups or belts which may extend 20 to 50 miles or more and often have their greatest length in parallelism with the course of the terminal moraines. Elsewhere drumlins are sparingly scattered here and there with intervals of several miles between them, this being often observed on the borders of their tracts of greatest abundance; and rarely a single typical drumlin, as Pigeon hill on Cape Ann, may be separated many miles from any other like accumulation of till.

It would be expected that the abundance or absence of drumlins must be determined, or at least influenced, by the varying contour and diversity in lithologic characters of the bed rocks; but I have been unable to discover this relation or dependence, if any exists. In southern New Hampshire, and southward to the neighborhood of Boston, the drumlins are finely developed on some portions of the low land near the coast, being spread over areas which would otherwise be nearly level; but at many places inland they are equally abundant among high irregular hills of rock. They seem as likely to be found on one side as another of any mountain or prominent hill range; and the altitudes at which they occur vary from the level of the sea to 1,500 feet above it on the hight of land between the Merrimack and Connecticut rivers. Interspersed with the tracts of plentiful drumlins are other tracts which have none. If their distribution has been mainly independent of the differences in topography and the limits of various rock formations, as seems to be true, we are brought to the alternative that it probably resulted from movements of the ice-sheet and the conditions of its erosion, transportation, and deposition of the drift.

*Geology of Wisconsin, vol. II, 1877, p. 50.

Besides the frequent arrangement of these hills and ridges of till in groups and somewhat definite belts, which are from a few miles to 10 or 20 miles wide, with intervening belts or irregular areas destitute of drumlins, a still more noteworthy feature of their geographic distribution is found in their occurring thus upon some extensive districts, while they are utterly wanting on larger portions of the great glaciated areas of North America and Europe. On this continent it seems probable that the districts where they are found, ranging from southern New Brunswick and Maine to northwestern Manitoba, may have been uncovered contemporaneously from the ice-sheet during the same general stage of its final recession.

Mr. Robert Chalmers has observed numerous drumlins on the east side of lake Utopia and between the Magaguadavic and St. Croix rivers in Charlotte, the most southwestern county of New Brunswick.* Under the name "whalebacks," Mr. G. F. Matthew describes these and other drumlins in the southern part of this province on an area extending from the St. Croix about 90 miles east to Upham township.†

Drumlins are reported in Maine by Prof. George H. Stone, the lenticular type prevailing in the western part of the state, while toward the east they also take the form of long ridges. In size and numbers, however, they are described as inferior to the drumlins of New Hampshire, Massachusetts, and New York.‡

The earliest mapping of drumlins in this country was done by the writer in 1878, under the direction of Prof. C. H. Hitchcock, for the Geological Survey of New Hampshire.§ Nearly 700 drumlins were noted in the southern half of this state, besides about 175 lenticular slopes of till. Farther north in New Hampshire such accumulations are absent or very rare. Some 130 drumlins in adjacent portions of northeastern Massachusetts and southwestern Maine were also noted on this map. The most important feature of the distribution of the drumlins in New Hampshire is their occurrence chiefly upon three belts which vary from 5 to 20 miles in width and extend 25 to 30 miles from northeast

*Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. IV, for 1888-89, p. 23 N.

†Geol. and Nat. Hist. Survey of Canada, Report of Progress for 1877-78, pp. 12-14 EE.

‡Proceedings of the Boston Society of Natural History, vol. XX, 1880, p. 434. Proceedings of the Portland Society of Natural History, March 11, and Nov. 21, 1881.

§Geology of N. H., atlas and vol. III, 1878, pp. 285-309, with heliotype.

to southwest. These tracts are separated by others of equal or greater width upon which scarcely any drumlins are found.

Profs. Shaler, Wright, Hitchcock, and Davis, and the present writer, have described the drumlins of Boston and neighboring areas, where they are admirably developed.* During the years 1890 to 1892 the drumlins of the entire state of Massachusetts have been mapped and carefully studied by Mr. George H. Barton, under the direction of Prof. N. S. Shaler, for the United States Geological Survey. Their total number is found to be about 1,500, counting, as in New Hampshire, the separate rounded summits of compound drumlin aggregations, where two or three of these hills, or sometimes more, are merged together at their bases.

From the vicinity of Spencer, Mass., a series of abundant drumlins, according to Davis, extends south to Pomfret in northeastern Connecticut. They probably also occur plentifully in other parts of this state, reaching southward to Long Island sound; for Round hill in Orange, near New Haven, described by Prof. J. D. Dana, appears to be a drumlin.†

New York has a magnificent area of drumlins, perhaps the most interesting in the United States, which stretches more than 60 miles from Syracuse westward nearly to Rochester, lying between lake Ontario and the "Finger lakes."‡ These hills are well seen along the New York Central and West Shore railroads.

*N. S. Shaler, "On the Parallel Ridges of Glacial Drift in eastern Massachusetts," Proceedings, Boston Society of Natural History, vol. XIII, 1870, pp. 196-204. Illustrations of the Earth's Surface: Glaciers, 1881, pp. 60-63. U. S. Geol. Survey, Seventh Annual Report, for 1886, pp. 321-2; Ninth Annual Report, for 1888, pp. 550-1.

G. F. Wright, Proc., B. S. N. H., vol. XIX, 1876, p. 58, and vol. XX, 1879, p. 217. The Ice Age in North America, 1889, chapter XI.

C. H. Hitchcock, "Lenticular Hills of Glacial Drift," Proc., B. S. N. H., vol. XIX, pp. 63-67.

W. M. Davis, Illustrations of the Earth's Surface: Glaciers, text describing Plate XXIV. Proc., B. S. N. H., vol. XXII, 1882, pp. 34, 40-42. "Drumlins," Science, vol. IV, pp. 418-420, with illustrations, Oct. 31, 1884. "The Distribution and Origin of Drumlins," Am. Jour. Sci., III, vol. XXVIII, pp. 407-416, Dec., 1884.

Warren Upham, "Glacial Drift in Boston and its Vicinity," Proc., B. S. N. H., vol. XX, 1879, pp. 220-234; "Marine Shells and Fragments of Shells in the Till near Boston," Proc., B. S. N. H., vol. XXIV, 1888, pp. 127-141, also in Am. Jour. Sci., III., vol. XXXVII, May, 1889. "The Structure of Drumlins," Proc., B. S. N. H., vol. XXIV, 1889, pp. 228-242.

†Am. Jour. Sci., III, vol. XXVI, 1883, pp. 357-361.

‡L. Johnson, "The Parallel Hills of western New York," Trans., N. Y. Acad. of Sci., vol. I, 1882, pp. 78-80; Annals, do., vol. II, pp. 249-266, with map.

D. F. Lincoln, "Glaciation in the Finger lake region of New York, Am. Jour. Sci., III, vol. XLIV, pp. 290-301, Oct., 1892.

Near Clyde and Lyons a considerable proportion of them are prolonged in ridges which rise with steep sides to sharply narrow crests, having lengths of two, three, or several miles from north to south in parallelism with the glaciation of the region. With these are many other drumlins having the typical lenticular contour, from which all gradations are seen to the prolonged sharp ridges. Another area of drumlins, occurring in less profusion and presenting only the lenticular form, lies between Adams and Carthage, in Jefferson county, between the east end of lake Ontario and the Adirondacks.*

In the drift-covered northern part of New Jersey drumlins are probably infrequent, only two examples being mentioned by Prof. R. D. Salisbury in his recent preliminary paper on the Pleistocene formations of that state.†

No drumlins have been found in Ohio, Indiana, and Illinois, by Mr. Frank Leverett, Prof. G. F. Wright, and others, who have thoroughly examined that area, mapping its terminal moraines and other drift deposits.

Next northwestward, however, drumlins are again encountered in great abundance and variety in the east part of Wisconsin. Professor Chamberlin, describing these and other till accumulations and the known areas of drumlins, in his address as vice president of Section E of the American Association in 1886, wrote as follows:

Somewhat allied to the true moraines are the special forms of aggregation of the subglacial débris, or—interpretation aside—of the great sheets of till. They present a richness of variety and of intergradation that almost defy classification. The list of forms embraces (*a*) till tumuli; (*b*) mammillary and lenticular hills; (*c*) elongated parallel ridges trending with the ice movement; (*d*) drift billows akin to the above but without individual symmetry or discernible parallelism of axes or definite arrangement, giving a smoothly undulatory contour to the surface; (*e*) crag and tail; (*f*) precrag and combings; (*g*) veneered hills, and a great residual congeries of irregular embossments and unclassifiable till hills. The most remarkable are the mammillary, lenticular, and elongated ridges, now frequently included under the term drumlins, which have become subjects of special inquiry. These have a fine development in southern New Hampshire, central and eastern Massachusetts, northeastern Connecticut and Nova Scotia, in all of which the elliptical or lenticular varieties prevail. They have a still more remarkable development in central New

*Bulletin, Geol. Soc. of America, vol. III, 1892, p. 142.

†Geol. Survey of N. J., Annual Report for 1891, p. 74.

York, where the elongated type predominates. They have an even more varied development in eastern Wisconsin, extending into the northern peninsula of Michigan, where all varieties, from till tumuli to the extremely elongated ridges, are abundantly developed, the number of individuals being probably not less than 5,000. About 1,000 drumlins have been mapped in New Hampshire, about 1,200 in Wisconsin, and large numbers in Massachusetts and New York. The total number within areas already known probably aggregates 10,000. These are almost wholly confined to the area of later drift.*

Throughout a large region farther northwest, comprising Minnesota, northern and central Iowa, South and North Dakota, and southern Manitoba, Prof. N. H. Winchell's and my own exploration and mapping of the drift and its terminal moraines have failed to discover any of the peculiarly moulded masses of till classed as drumlins.

Beyond this region, drumlins have been reported only by Mr. J. B. Tyrrell in lake Winnipegosis, where they form groups of lenticular and elongated low islands.†

In Ireland, Scotland, and northern England, drumlins are very abundant or frequent on many tracts, as described by Kinahan, Close, James Geikie, and others. It seems probable that they will also be found to have a considerable development in northern Germany and northwestern Russia. On the north and west side of the Baltic Sea, however, in the region where the European ice-sheet was thickest, they are infrequent or altogether absent, according to Baron de Geer, who, in excursions with me a year ago to see the drumlins in the vicinity of Boston, stated that no similar hills of till have been observed by him in his extensive examination of the drift formations of Scandinavia.

Subglacial and Rapid Deposition shown by Structure.—The till forming the drumlins invariably exhibits the characteristic features of subglacial till or ground moraine, excepting its superficial portion which was englacial and superglacial when the ice-sheet melted away.‡ Many boulders, which are commonly strown plentifully on the surface of the drumlins, appear to have fallen upon them from the receding ice-sheet, together with a stratum

*Proc., A. A. A. S., vol. XXXV, p. 264.

†Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. IV, for 1888-89, p. 22 A. Bulletin, G. S. A., vol. I, 1890, p. 402.

‡"Inequality of Distribution of the Englacial Drift," Bulletin, G. S. A., vol. III, 1891, pp. 134-148. "Criteria of Englacial and Subglacial Drift," Am. Geologist, vol. VIII, pp. 376-385, Dec., 1891.

of the till that varies from one foot to a few feet in depth near Boston, but is sometimes 10 to 15 feet thick on the tops and flanks of drumlins in New Hampshire. This upper part of the till is comparatively soft and easy to dig, while its main portion below is so compact that it must be picked and is far more expensive in excavating. The probable cause of the contrast in hardness was the pressure of the ice-sheet upon the lower till during its accumulation, while the upper till was contained in the ice and dropped loosely at its melting. Occasionally a thin layer of sand or gravel lies between the englacial and subglacial till, as on the top of the drumlin named Convent hill in Somerville, Mass., where the upper 3 feet of the till, forming the surface, are underlain along an observed distance of several rods by a bed of sand from 1 to 3 feet thick.

Subglacial till is further distinguished from that which was finally dropped from the departing ice by its smaller rock fragments, which are mostly less than two feet in diameter, and sometimes consist only of pebbles, cobbles, and small boulders not exceeding half this size, though often it also contains large boulders; by the glacially worn faces of many of these stones, which are frequently marked with striæ; and by traces of a peculiarly bedded structure, in parallelism with the surface. The last feature is especially characteristic of the till in drumlins, excepting its upper few feet. Although boulders, gravel, sand and clay are thoroughly commingled, the deposit is imperfectly laminated and tends to separate and crumble into thin flakes. This is frequently noticeable in a fresh excavation, but is most distinctly seen after a few weeks of exposure. It shows that the ice in its passage added new material to the surface of the ground moraine, which generally lay undisturbed beneath.

To a depth that commonly varies from 5 to 10 feet on low or moderately undulating tracts, but is often 15 to 20 feet or more on the drumlins, the color of the till is yellowish gray or buff, while at greater depths it is a darker and bluish gray. This difference in color is due to progressive weathering, the influence of air and water upon the iron contained in the till having changed it in the upper part from protoxide combinations to the hydrous sesquioxide. On low tracts the weathering of the till is often limited to its comparatively loose englacial portion, but it has generally extended beyond into the subglacial till of the drumlins and lenticular slopes

My observations of the sections of drumlins, before mentioned, forming Third and Fourth Cliffs in Scituate, Mass., and islands in Boston harbor, and the prevailing trends of the drumlins near Boston in parallelism with the latest deflected glacial currents, convince me that these hills were somewhat rapidly heaped up beneath the retreating ice-sheet within a few miles back from its margin. Peculiar dark bands, evidently representing successive stages of deposition, were noted in the till of the northern part of Third Cliff. Their number is seven or eight, each six to twelve inches thick, varying from one to three or four feet apart, continuing separate along an extent of about 200 feet, with no branching or inosculation. The portion of the till thus banded has a vertical width of 15 to 20 feet and a dip of about five degrees northward, being included between 20 and 45 feet above the sea. It is more inclined than the overlying surface of the drumlin, which is there about 60 to 55 feet above the sea, or than even the steepest slope of the surface farther down. No stratified layers or seams of modified drift occur in the banded part of the till, which is nearly like the remainder of the extensive deposit of till in this section, excepting that it has somewhat more sandy and porous layers alternating with somewhat more clayey and therefore impervious layers, the latter being noticeable because they retain the moisture more persistently and have a slightly darker color. But no definite line of demarcation separates these layers, there being instead a gradual change which occupies a thickness of several inches. Boulders and gravel are indiscriminately mingled through the whole mass, which is the ordinary boulder-clay or till; and these alternations in the proportions of clay seem probably attributable to the slightly varying conditions of alternating summer and winter, affecting the rate of motion of the ice-sheet and its tendency to deposit its ground moraine on the surface of the drumlin. If this is the true explanation, the yearly addition of till to that part of the section averaged 2 or $2\frac{1}{2}$ feet, and the accumulation of the entire drumlin of Third Cliff required probably not more than 25 or 30 years.

Though such banded structure, approximately parallel with the surface, has not been found in the drumlins of New Hampshire and inland parts of Massachusetts, nor even of the vicinity of Boston, excepting within close proximity to the sea, it is yet frequently observable in the drumlins of the islands of Boston harbor. For example, it is finely developed in the cliff forming the northeast end of Peddock's island, where five or six such bands are separated by intervals that vary from three to six feet; at the southwest end of Long island, where a single dark band about half way up the cliff, or 30 to 40 feet above the sea, extends fully 400 feet; and at the south end of Spectacle island, where two dark bands six or eight feet apart are distinctly seen along a distance of at least 150 feet at a similar elevation above the sea and below the top of the cliff as on Long island. In all these sections, as in Third Cliff, the dark bands have anticlinal dips, which are somewhat more inclined than the overlying arched surface.

Very rapid accumulation of ground moraine is shown by Fourth Cliff, for that drumlin, soon after the beginning of its formation, received a wedge-shaped deposit of true subglacial till, increasing from nothing to six feet in thickness along its exposed extent of about 100 feet, laid down on the southern slope during a small part of the time, probably only one summer, if so long, in which the central portion of this hill was being formed by the subglacial deposition of 10 to 20 or 25 feet of stratified sand and gravel, which in their continuation southward enclose the wedge of till. Under all this modified drift, the base of the section at its center is a low dome-shaped deposit of till, which, like the thick arch of till forming the upper and outer part of the drumlin, is divided from the modified drift by a well defined line with which the obscure lamination of the till and the bedding of the sand and gravel are parallel. No evidence of erosion, nor of tumultuous pushing forward, was anywhere seen; but instead the whole section appears to represent continuous deposition. The very hard and compact condition of the till, and its characteristic flakiness, which I have spoken of as lamination, both below and above the modified drift and in the enclosed wedge, indicate that it was deposited as a ground moraine beneath the pressure of the ice-sheet, instead of as englacial till falling loosely from the ice when it melted. The conditions leading to the accumulation of the basal till were followed by such as caused the modified drift to be spread over it, the latter apparently requiring no longer time than a single summer or the portion of the year attended by abundant ice-melting; but on the southern slope the deposition of this sand and gravel was for a short time interrupted while the wedge of till was being amassed. Subsequently the accumulation of till began again over all the dome of sand and gravel, and continued thenceforward until the formation of the hill was completed and the overlying ice disappeared.

In addition to the evidence in the structural features of the drumlins, indicating that they were accumulated rapidly during the closing stage of the Glacial period, a strong argument toward the same conclusion is afforded by the prevailing east-southeast trend of the longer axes of these hills about Boston, while the striation on the bed-rocks is mostly south-southeast, the difference between the two courses being forty-five degrees. Recent examination of the glacial striæ in the city of Somerville, however, lying next northwest of Boston, shows that, besides their common south-southeast courses, they are in many localities deflected to the east-southeast and even sometimes to due east. Elsewhere in all the districts characterized by abundant drumlins in this country and the British Isles, their longer axes and the striæ are parallel; and it seems sure that both were determined by the currents of the ice-sheet. Their difference in direction in the neighborhood of Boston I believe to be due to a deflection of the motion of the ice there during its final melting. Through the time of its maximum thickness and extent the ice-sheet moved south-southeastward across this area, and reached to the terminal moraine of Long Island, Block Island, Martha's Vineyard, and Nantucket; and onward the course of its border was probably east-northeast along the submarine plateaus of the Fishing Banks. But when a mild climate began to cause the glacial boundary to recede northward, the melting probably advanced faster upon the area of the gulf of Maine than upon southern New England, so that the ice-front became indented by a deep embayment east of Massachusetts, toward which the latest currents along the coast were deflected. The formation of the drumlins about Boston seems to have taken place wholly during the time of deflected glacial movements, the ground moraine being massed in these hills on account of inequalities in the force and direction of the overriding ice-sheet, when its receding border was probably only a few miles distant. Farther inland throughout Massachusetts, Mr. Barton finds the trends of the drumlins prevailingly parallel with the striation, but with occasional exceptions where the longer axes of drumlins vary much from this course, probably because of small indentations in the glacial boundary and consequent divergence of the latest ice-motion from its previous direction.

If the dark bands noted in the till of Third Cliff, Peddock's island, and elsewhere, are marks of accumulation in successive years, which seems highly probable, the drumlins of Boston and vicinity received, at least in some instances, from one to six feet of till yearly deposited over their whole surface, so that the accumulation of these hills to their hights of 50 to 150 or 200 feet required only from two or three decades to a century of years. Indeed, where they exhibit no such banding, I have thought that sometimes their entire formation may have been more rapid, so that the most massive drumlins, like the largest esker ridges, were probably deposited in so short a time that their beginning, growth, and completion would occupy considerably less than a man's lifetime. The drumlins appear to have been heaped up beneath the ice-sheet within a few miles back from its margin, or perhaps occasionally within even less than one mile, as seems to be suggested by Mr. Barton's observations. Where they are scattered over any extensive area, probably they were not all in progress of deposition contemporaneously, but were successively accumulated as the ice-margin retreated.

Questions concerning the Action of the Ice-sheet.—While some steps of progress seem to be gained by the foregoing observations and discussion, here abridged from my latest paper on this subject three years ago, toward a knowledge of the manner and time of deposition of the drumlins, the questions as to how the ice-sheet could amass these hills, and why they are distributed in abundance upon some districts, but are absent or represented only by a few examples upon other large areas, remain to be answered. Their distribution, however, is to so large a degree independent of topographic features, and of the character of underlying rocks, that the explanation of their origin and grouping appears more likely to be found in variable conditions of the glacial movements resulting from secular climatic changes during the final melting of the ice.

Probable Accumulation of the Drumlins from Englacial Drift.

Objections to former Theories.—Several theories of the way in which the ice-sheet produced the drumlins have been suggested.

The earliest was by Shaler in 1870, who supposed these hills in the vicinity of Boston to be remnants spared from the fluviatile and tidal erosion of a once continuous sheet of drift, which had been contained in a glacier that descended the Charles river valley. His later view is similar, but attributes the very thick drift sheet of this hypothesis to deposition during the earlier of two epochs of glaciation, and its erosion partly to sea and river action during an interglacial epoch, but mainly, for the peculiar sculpture of the drumlins, to excavation and removal of the drift from all the intervening areas by the later glaciation. To accord with this view, however, the terminal moraines of the later ice-sheet must vastly exceed their very moderate observed volume. Another objection, pointed out by Salisbury, is that the drumlins appear to be composed wholly of the newer drift.

Hitchcock and Wright have thought the drumlins to be perhaps the material of terminal moraines swept over and massed in these peculiar forms by subsequent farther advances of the ice-sheet. If this view were true, the till of the drumlins could not have its nearly uniform character, but would contain here and there remarkable aggregations of boulders, and frequent irregular enclosures of sand and gravel would be found, representing the kame deposits and lenticular beds of modified drift which so commonly make up considerable parts of the terminal moraines. Salisbury remarks that neither the distribution nor the composition of the drumlins seems to favor this hypothesis, and he therefore believes that they were built up beneath the ice, not being fashioned from hills overridden by it.

Mr. Clarence King and Prof. J. D. Dana have conjectured that the drumlins, at least in some cases, were made by superglacial streams, charged with drift, pouring through crevasses or a moulin to the land surface, there depositing their drift, which afterward by the onflow of the ice would be subjected to its pressure and sculpturing. This explanation lies under similar objections with the last.

Kinahan and Close in Ireland, Prof. James Geikie in Scotland, and Davis and Salisbury in this country, look on the drumlins as analogous to the sand bars of streams. Professor Davis writes:

> In view of the irregularity of the surface on which the ice-sheet moved, and of the greater weakness of some rocks than others, we must suppose an irregular velocity in the motion of the ice and an

unequal distribution of the rubbish beneath it. If the faster motion at one place causes an excess of erosion there, the slower motion at another place may bring about an excess of deposition. This difference of action is known to prevail between the central and marginal parts of glaciated areas; and the local accumulation of drumlins in an intermediate region gives a smaller example of these two parts played by the ice. If the causes of the irregular motion of the ice lie in the general form of the country, the location of faster and slower currents will be relatively permanent; the districts of faster currents would be found where the greatest volume of ice is allowed to pass, and some of the points of retardation may be the seats of long continued drumlin growth.*

For accordance with this theory, the areas bearing drumlins should be determined chiefly by the topography and rock formations, which, however, seem to have exerted little influence. The rapid accumulation of the drumlins appears also inconsistent with the belief that they were mostly supplied from drift immediately before eroded from the land surface and transported by subglacial dragging to its place in these drift hills.

The origin of the drumlins may be better understood, or at least to the writer it seems more intelligible, if we inquire how the drift which had been englacial until the time of departure of the ice would be deposited.

Transportation of Drift into the lower part of the Ice-sheet.—It is evident that the ice-sheet in its passage over a mountainous or hilly country must gather much drift into its lower part, to as great hight as the altitude of the mountains and hills, by grinding off and plucking away detritus and blocks of rock from these elevations, thence carrying them forward enclosed within the ice many hundreds of feet, and in the lee of the White, Green, and Adirondack mountains even thousands of feet, above the ground. But it has seemed to some geologists difficult to account for the transportation of much drift into the ice from moderately undulating or plain districts, such as make the greater part of the drift-bearing areas of our continent and of Europe. On these nearly flat lands, however, I find at localities in Minnesota and Manitoba good proofs, as they seem to me, that the thickness of the englacial drift was sometimes as much as forty feet near the ice-border where it was amassing prominent terminal moraines, and on lines or belts where confluent ice-currents met from broad

*Am. Jour. Sci., III, vol. xxviii, p. 415.

regions on each side.* Similarly in England, according to the observations of Mr. G. W. Lamplugh, a confluent ice-sheet flowing from Scandinavia and Scotland was pushed up on the Yorkshire coast, bringing much englacial drift, with marine shells, which it had eroded and gathered up from the shallow and almost level basin occupied before the Ice age and again afterward by the North sea.†

The manner in which the ice gathered drift into its basal portion from any plain tract seems to me explainable by a consideration of the currents of outflow toward its border. In the central area of the ice-sheet the currents of its upper and lower portions probably moved outward with nearly equal rates, the upper movement being slightly faster than at the base. Upon a belt extending many miles back from the margin, however, where the slope of the ice-surface had more descent, the upper currents of the ice, unsupported on the outer side, would move much faster than its lower currents which were impeded by friction on the land. There would be accordingly within this belt a strong tendency of the ice to flow outward with somewhat curved currents, tending first to carry the onwardly moving drift gradually upward into the ice-sheet, and later to bear it downward and deposit it partly beneath the edge of the ice and partly along the ice boundary.

Ablation causing Englacial Drift to become Superglacial.—Whenever the warm climate terminating the Glacial period extended unchecked through many years, the depth of the ablation or superficial melting of the outer part of the ice-sheet was probably not less than 15 to 25 feet each summer, as has been observed on the Muir glacier in Alaska‡ and on the Mer de Glace in Switzerland.§ At such rates of melting any district enveloped by ice 2,000 to 4,000 feet thick, as was true of the central portions of New England and doubtless also of a broad belt thence west to the Laurentian lakes and to Minnesota and southern

*Geol. and Nat. Hist. Survey of Minnesota, Ninth Annual Report, for 1880, pp. 322-326; Final Report, vol. I, 1884, pp. 603, 604. Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. IV, for 1888-89, pp. 38-40 E.

†Quart. Jour. Geol. Society, London, vol. XLVII, 1891, pp. 384-431, with maps and sections.

‡H. F. Reid, in National Geographic Magazine, vol. IV, pp. 31, 38, March, 1892.

§Prestwich's Geology, vol. I, p. 176.

Manitoba, would be uncovered in one or two centuries, and the recession of the glacial boundary would average probably a half mile or more yearly.

During any long series of years when the ice-sheet was being thus rapidly melted, its outer portion to a distance of probably twenty miles from its boundary, being reduced by ablation to a thickness ranging from 100 feet and less upward to 1,000 feet, would bear on its surface, especially in the valleys and hydrographic basins of its melting, much drift which had been before contained in the higher part of the ice. Only scanty englacial drift, mainly consisting of boulders borne away from hills and mountains, appears to have existed at altitudes exceeding 1,000 or 1,500 feet; but all the lower ice probably contained an increasing proportion of detritus and boulders which had been brought into it from below by the upward movements due to faster flow of the central and upper glacial currents than of those retarded by friction on the ground. The thinned border of the ice-sheet upon the belt having a remaining thickness of less than 1,000 feet would therefore become covered with drift, as Russell has described the borders of the Malaspina glacier or ice-sheet, which stretches from the Mt. St. Elias range to the ocean.*

Stratum of Superglacial Drift made again Englacial by increased Snowfall and by Advance of the thicker portion of the Ice-sheet.—At many times the general recession of the ice-sheet was temporarily interrupted. The return of a prevailingly cold climate for several decades of years, or occasionally, as we may suppose, for a century or more, brought increased snowfall, which sufficed to hold the ice boundary nearly stationary, perhaps frequently first having pushed it again a considerable distance forward. The thick ice lying far back from the border may then have flowed over its previously thin and drift-covered outer belt, aiding with the new snowfall to envelope the once superglacial drift stratum within the ice-sheet. These halts or re-advances, if the front of the ice had a nearly constant position during several years, became marked by terminal moraines, of which I have mapped a series of eleven in consecutive order from south to north in Minnesota, North Dakota, and Manitoba, while Mr.

*National Geographic Magazine, vol. III, 1891, pp. 53-203, with 19 plates and maps. Am. Jour. Sci., III, vol. XLIII, pp. 169-182, with map, March, 1892. AM. GEOLOGIST, vol. VIII, p. 384, Dec., 1891.

Leverett has traced a still larger number through Illinois, Indiana, and Ohio. With the increased thickness and steeper gradient of the outer belt of the ice-sheet while the recession of its boundary was slackened, wholly stopped, or changed to a re-advance, due mainly to very abundant snowfalls, much drift which had been formerly exposed on the ice surface would become again englacial, so that a stratum of drift several feet thick might be enclosed in the ice at an altitude increasing inward from less than 50 feet to 500 feet or more.

Ice Currents massing the Englacial Stratum into Drumlins.—The upper current of the thickened ice above the englacial bed of drift would move faster than that drift, which in like manner would outstrip the lower current of the ice in contact with the ground. Close to the glacial boundary, whether it halted and even re-advanced or merely its retreat was much slackened but did not entirely cease, which last seems probably to have been the case with the drumlin areas of Massachusetts and New Hampshire, the upper part of the ice must have descended over the lower part. This differential and shearing movement, as I think, gathered the stratum of englacial drift into the great lenticular masses or sometimes longer ridges of the drumlins, thinly underlain by ice and overridden by the upper ice flowing downward to the boundary and bringing with it the formerly higher part of the drift stratum to be added to these growing drift accumulations. The courses of the glacial currents and their convergences to the places occupied by the drumlins were apparently not determined so much by the topography of the underlying land as by the contour of the ice surface, which under its ablation had become sculptured into valleys, hills, ridges, and peaks, the isolation of the elevations by deep intervening hollows being doubtless most conspicuous near the ice-margin.

In New England, on account of the absence or extreme rareness of any beds of modified drift which give evidence of having been covered by a re-advance of the ice, the till of the drumlins, according to this view, appears to have been collected in its present masses in the basal part of the ice-sheet, while a moderate thickness, probably seldom more than 50 or 100 feet, of ice lay beneath. Over the drumlins a somewhat greater thickness, perhaps varying from 200 to 500 or 1,000 feet, of ice formed largely from the snowfalls of recent years or the immediately preceding century or more, with probably much addition from the thick, inner part of the ice-sheet, containing, from whichever source, little or no drift, passed and moulded these hills in their smoothly oval, or round, or elongated forms.

It is thus readily seen why the amount of finally englacial drift upon the surface of drumlins is usually less than on intervening tracts of low ground and on those parts of the drift-bearing area from which the ice-sheet was more rapidly melted away.

We can also understand why these accumulations are so frequently found capping the top of low hills of the bed-rocks, since these projected through the ice that lay beneath the superglacial, and afterward again englacial drift stratum, and so were obstacles to favor an aggregation of that drift, either as a complete drumlin resting on the hill of rock, or as a lenticular slope of till, of which abundant examples are found in New Hampshire, collected on the stoss or the lee side of the rock hill and occasionally in slopes of this form, covering both these most exposed and most sheltered sides of the hill thickly and its intervening flanks thinly, with visible outcrop of the rock only at its summit.

Powderhorn hill, in Chelsea, Mass., one of the largest drumlins near Boston, rising about 200 feet above its base, which is near the sea level, and having an exceptionally elongated form, with the length of three-quarters of a mile and one-fourth as great width, affords evidence that a slight thickness of ice remained beneath it when it was accumulated. Extensive excavations, 20 to 40 feet deep, in each end of this drumlin consist wholly of till, with no trace of any bed or seam of stratified drift. In one of these sections, about 30 feet high, on the north side of its southeastern end, I observed a nearly vertical, irregular course of fracture, from one to six inches wide, filled with sand and fine gravel brought by percolating water, where this long hill had suffered a slight dislocation in sinking as the underlying ice melted. Such fractures, extending deeply into the hill, were also found in the construction of the reservoir on its top, which gave much trouble by leaking, until the bottom was made impervious with cement. The till where not so fractured is water-tight, and numerous reservoirs on other drumlins near Boston have been free from this difficulty. The narrowness of Powderhorn hill, in proportion to its length, probably caused it to sink more unequally than most of the drumlins in this district.

On some other areas, and perhaps more commonly, drumlins may have been formed from the englacial stratum of drift during a time of re-advance of the ice-sheet, carrying the drift forward so that it would be accumulated on a land surface. This appears to have been the case in central New York, where Prof. W. M. Davis finds that the sections of drumlins frequently show stratified gravel and sand underlying the till, and that often the relationship of these formations is such as to prove that the stratified beds were somewhat eroded before the deposition of the till. But the absence of such sections in Massachusetts and generally in New England makes it probable, as stated, that here the recession of the ice was continued, though with a much diminished rate, while the drumlins were being amassed.

Review of Objections to this Explanation.—At first sight, this explanation of the accumulation of the drumlins appears to be opposed by two conspicuous objections, which must be answered. The first is the local derivation of much of their material. Where the peculiarities and restricted limits of the adjacent rock formations on the north permit an approximate determination of the distances of transportation of the drift forming the drumlins, it is found that a large part, sometimes more than half, has been carried only a few miles. It seems surprising that local material should constitute so important an element of the drift contained within the ice at considerable hights, until we consider how fast it would be uplifted by even a very slight upward inclination of the basal current of the ice. If the drift eroded from any place was carried up with an average ascent of only one degree, it would rise, within one mile, to an altitude of 92 feet above the ground, and within two to three miles would be as high as the tops of the most prominent drumlins. Currents ascending at this rate, or even two or three degrees or more, may very probably have existed in the lowest part of the ice-sheet, on account of the acceleration of its upper currents, within distances from 20 to 50 miles or more back from its boundary. By these currents much drift eroded from the land surface would be gradually incorporated in the comparatively sluggish lower part of the ice, reaching altitudes 100 to 1,000 feet above the ground within a few miles from its sources.

When the boundary receded, the upper currents of the outer belt of the ice, upon a width of probably ten miles, would pour down toward the open land, causing the deposition of much subglacial till; and whenever a stratum of the englacial drift became covered with much new ice, it would probably be aggregated englacially or altogether subglacially in drumlins. The drift that had been eroded and lifted into the lower part of the ice during many centuries might thus be rapidly accumulated in the drumlins during only a very small fraction of the time that had been required for its being stored up in the ice. Through such processes I can better understand the origin of these prominent drift hills, than by any method that I am able to imagine for nearly contemporaneous erosion, subglacial transportation, and deposition of their till. Moreover, I find great difficulty in forming a conception of convergent basal currents powerful enough, in spite of their friction on the land, to amass these hills; but the inequalities of contour of the outer belt of the ice, as irregularly thinned by ablation, may well have produced upper and central currents of sufficient energy to sweep the englacial drift stratum into irregularly grouped and scattered or even solitary drumlins, when new ice and snowfields added a considerable depth over all the previous drift-covered surface of the ice sheet.

The second objection alluded to arises from the abundance or frequency of glaciated stones and boulders in the till of the drumlins and from its compactness, flaky lamination, and other features which prove it to be subglacial till or ground moraine. If this drift was englacial during a considerable time and became massed in these hills beneath only a few hundreds of feet of ice, could it present so impressive characteristics of subglacial accumulation under heavy pressure? To this question we must reply that the stratum of englacial drift would be subjected to much wear of its boulders and smaller rock fragments as they were carried forward with shearing and sliding motion to the drumlin accumulations, and that in becoming lodged on the surface of the drumlins or on other and low deposits of subglacial till, they would be further striated and planed. The previously englacial drift in being so transported and deposited would acquire all the marks of ice-wear which the till of the drumlins exhibits, and the pressure of 500 to 1,000 feet, more or less, of solid ice flowing downward across it would seem adequate to produce its very hard and compact condition. We are thus able, as I believe, to account for all the differences between these deposits and the mostly unworn drift which fell loosely on the surface from an englacial or superglacial position when the ice disappeared.

COMPARISON WITH TERMINAL MORAINES, KAMES, AND ESKERS.

My study of the glacial lake Agassiz, under the direction of Prof. T. C. Chamberlin, for the United States Geological Survey and partly for that of Canada, shows that several large terminal moraines, marking pauses or re-advances interrupting the general glacial recession, were accumulated contemporaneously with the existence of that lake, while yet the whole duration of Lake Agassiz was apparently only about a thousand years.* The rapidity of formation of the moraines was thus similar with that of the drumlins, and both seem to have been made possible only by the large amount of the englacial drift. The fast retreat of the ice indicates that probably its melting border then had usually a more steeply sloping surface than in its time of greatest extent to the south, and that consequently the rate of motion of the outer part of the ice-sheet was commonly increased during its final melting. Any pause of the retreat for even a few years would therefore form a moraine, though the outer belt of the ice may have been generally too steep to expose much superglacial drift. But during some stages of the recession we may conclude that considerable tracts of the ice-border were so thinned by ablation that much englacial drift became superglacial, with the result that when again a colder climate brought a temporary thickening of this marginal ice the previously superglacial stratum of drift was chiefly amassed in drumlins. The known drumlin areas of New Brunswick and New England, New York, Wisconsin, and Manitoba, would therefore be expected to belong to the same stages of the closing part of the Ice age. This would imply what seems from other reasons not improbable, that the outermost moraines in the states east of Ohio and on the east side of the driftless area in Wisconsin correspond to some of the inner and late moraines in the greater part of the region of the Laurentian lakes and the upper Mississippi, as perhaps the exceptionally massive Leaf hills, Itasca, and Mesabi moraines, which are the ninth, tenth, and eleventh of the series in Minnesota.

*Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. IV, for 1888-89, pp. 50, 51 E. AM. GEOLOGIST, vol. VII, pp. 224-6, April, 1891.

Again, my studies of the very massive kame deposits forming the greater part of the outermost terminal moraine on Long Island eastward from Roslyn, of the large kame called the Devil's Heart, rising in a somewhat conical hill 175 feet above the adjoining country south of Devil's lake in North Dakota, and of the esker named Bird's hill, seven miles northeast of Winnipeg, seem to me to demonstrate, beyond all doubt, that their material, and probably likewise that of kames and eskers generally, was supplied by superglacial streams from the plentiful englacial drift, and could not have been brought from drift beneath the ice by subglacial drainage.

View of the Ice Age as One Glacial Epoch.

In conclusion, I deem it a duty to state that this reference of the drumlins, terminal moraines, kames, and eskers, to rapid accumulation from previously englacial drift during the departure of the ice, seems to me better accordant with the view that the Ice age comprised only one great epoch of glaciation, attended by oscillations of the ice-border, than with the alternative view which supposes the ice-sheets to have been at least once and perhaps several times almost entirely melted away, afterward being restored by recurrent glacial epochs. This belief in the unity of our glaciation I held during my work on the New Hampshire Geological Survey in the years 1874 to 1878; but in my ensuing work on the survey of Minnesota, the peat and forest beds enclosed between deposits of till in that region led me to accept the duality or plurality of glacial epochs as taught by Croll, James Geikie, N. H. Winchell, Chamberlin, Shaler, McGee, Salisbury, and at present by most American glacialists. The recent statement by Prof. G. F. Wright of the evidences for the unity of Quaternary glaciation as the more probable view,* expresses a similar opinion with that to which I have been gradually returning, during the past year or longer, through the guidance of my investigations in this field. Moraines and drumlins are effects of secular vicissitudes of climate on the border of the departing ice-sheet, which I think to have owed its existence to great altitude of the land at the beginning of the Glacial period, to have been attended when at its maximum extension and volume by depres-

*"Unity of the Glacial Epoch," Am. Jour. Sci., III, vol. XLIV, pp. 351-373, Nov., 1892.

sion of the land on which it lay, and to have witnessed, during the retreat and removal of its load, a progressive re-elevation of the same area to its present hight.

For Europe, also, after reading the recent very ably written article by Prof. James Geikie,* in which he argues for five distinct epochs for glaciation, I think that there, as here, it is more reasonable to refer the whole of the glacial drift to a single glacial epoch, with moderate fluctuations in the extent of the ice-sheets and glaciers. In thus differing from this eminent glacialist and from Wahnschaffe in Germany, Penck in Austria, and DeGeer in Sweden, who are of the same opinion with Geikie, that there were long mild interglacial epochs in Europe, I come into agreement, on this question, with other distinguished European glacialists, as Lamplugh in England, Falsan in France, and Holst in Sweden, who hold that the Quaternary reign of ice was essentially a unit. But this present state of our division under the two opinions surely calls for much further observation and candid study that ultimately the truth may be confidently known, on whichever side it may be.

THE GEOLOGIC STRUCTURE OF THE BLUE RIDGE IN MARYLAND AND VIRGINIA.

By Arthur Keith, of the U. S. Geological Survey, Washington, D. C.

In the following pages there will be discussed the belt of rocks in Virginia and Maryland, lying between the Shenandoah and Cumberland valleys and the Piedmont plain. Attention will be given chiefly to their structural relations as they have been brought out by recent discoveries of fossils. The topographic features of the belt are in brief (1) the great limestone valley on the west, (2) the Jura-Trias plain on the east, and (3) between them the mountain belt which consists of the South Mt.-Blue Ridge chain and Catoctin-Bull Run Mt. chain enclosing a broad level valley. The topography is the direct result of differential erosion among hard and soft rocks, and accordingly is a key to their areal distribution. The mountains are formed by sandstones and the intermediate valley by granites and schists. In passing northward through Maryland the granite areas rapidly lessen and disappear, and the valley contracts to insignificant dimensions.

*"On the Glacial Succession in Europe," Trans., Royal Society of Edinburgh, Vol. XXXVII, pp. 127–149, with map, May, 1892.

South Mt. and Blue Ridge have been the subjects of numerous discussions in previous years, and publications concerning them have been made by Rogers Bros., Hunt, Fontaine, Leslie, Frazer and Geiger and Keith. All of these discussions have been based on physical evidence alone and have scarcely brought out the complexity of the chain.

In 1891 Lower Cambrian fossils were found in the Blue Ridge at Balcony Falls, Va., by Walcott, and in August, 1892, he found Lower Cambrian fossils at Mt. Holly at the north end of South mountain and in the rocks of York valley, in Pennsylvania. In the latter end of August the writer accompanied Walcott through the mountain belt in Maryland and Pennsylvania with the purpose of finding fossils, and establishing the age of the entire chain. Search was directed especially to the sandstones and shales forming the mountain ranges and was abundantly rewarded. One layer in particular, the topmost one, yielded fossils in greatest abundance wherever tested. (The fossils will be described by Mr. Walcott in the American Journal of Science for December.) Subsequently the structure of the mountain belt was worked by the writer in this new light, from the Pennsylvania line southward to Thoroughfare Gap in Bull Run mountain and Front Royal along the Blue Ridge. Lower Cambrian fossils were found as far south as Manassas Gap in the Blue Ridge.

The rocks of the mountain belt fall into two classes, sedimentary and igneous, each with several divisions. The igneous rocks will be fully described in Am. J. Science for December, by Prof. G. H. Williams, and only briefly touched upon here.

Broadly considered, the region is a broad anticline and successively younger rocks appear east and west from the nucleus of igneous rocks. This arch is crumpled into several synclines and broken by faults that follow the mountain lines quite closely. The resultant structure is quite complicated, and there are very few places in which a normal and complete section can be found.

Five types of sedimentary rock occur: (1) the Siluro-Cambrian limestone of the great valley, (2) fine calcareous white sandstone, (3) greenish gray sandy shales with thin sandstone beds, (4) massive white sandstone in places conglomeratic with streaks and bands of black, (5) shale, usually black and slaty. As pointed out by Geiger and Keith, these types occur in distinct bands following the lines of structure. The fine sandstone caps a line of knobs in a synclinal axis next the valley limestone; the massive sandstone follows the syncline of the main ridge; and between the two sandstones lies a slope or valley of shales. Southward from the Potomac the two sandstone types become very much alike; northward they diverge and their differences are accented.

On structural grounds alone the two sandstones should be equal to each other in age as they occupy parallel synclines and the same shale passes under both.

On this hypothesis, the massive bed would represent shore accumulations and the fine sandstone the off-shore deposit. Even then the narrow limits of the change render it very abrupt.

Organic evidence, however, does not bear this out. As has been stated, fossils were very numerous in the fine sandstone and a few were found in the sandy shales. In the massive sandstone and the black slaty shale beneath it none were discovered. This difference in organic contents is as marked and persistent as the textural difference between the beds, and could hardly have been possible in synchronous deposits a mile or less apart.

The age of the massive bed of sandstone must be determined by structure in default of fossils. Over the fossiliferous beds lay the valley limestone, as determined by the sequence at York, Pa., and at Balcony Falls, Va. If, then, the limestone lay directly over the massive sandstones, the two sandstones must be the same in age; if no limestone rested on the sandstone the latter would presumably be older than the sandy shale. In the latter case sandy shales might be expected to occur above the sandstone at some point. Search was made for such places and several were found, two of them being indubitable. One was immediately northwest of Monterey, Pa., on the Blue Ridge, near the Maryland line; the other was on the Blue Ridge, six miles northeast of Front Royal, in Virginia. In each of these cases a syncline of the massive quartzite was overlain by sandy shales for a few miles. A similar sequence extends along the east side of Catoctin mountain for about ten miles and appears to be complete west of Frederick. There all the sandstones and shales of the mountain dip east under the Frederick limestone. The resemblance between this section and the York section is striking, and each contains the same varieties of massive and slaty limestones and limestone conglomerates. The York limestone is largely Cambrian and the resemblances of structure and composition indicate that the Frederick limestone is also Cambrian. North and south from this section the limestone is soon covered by the Jura-Trias sandstones, and its contact with the sandstones is not of sufficient extent to be free from doubt. As a corroboration of the sequence made out in other places it is good but not sufficient for independent proof.

With the discovery of the sandy shales overlying the massive sandstone the sequence was established as follows:

(1.) *Blue banded and mottled limestone*, with thin beds of slaty limestone, sandy shale, sandy limestone, and limestone conglomerate, Cambrian fossils.
(2.) *Fine grained, white sandstone*, with beds of shale. Lower Cambrian fossils .... 250 feet
(3.) *Gray sandy shales*, with beds of sandstone abundant near the middle. Scolithus and Lower Cambrian fossils. 1,200 to 1,500 ft
(4.) *Massive white sandstone*, with bluish-black bands, feldspathic and in places conglomeratic...... ....1,000 to 1,200 ft
(5.) Gray and black slaty shales ....0 to 400 ft
(6.) Igneous rocks.

With the above sequence it is necessary to assume several faults to account for the present attitudes of the rocks. The fine sandstone only once dips under the limestone, and then for only half a mile; the massive sandstone rarely passes under the sandy shale; and the igneous rocks occasionally pass over the massive sandstone. Thrust-faults, therefore, exist between the limestone and sandstone belts and between the two sandstone belts, by which the anticlines have been broken and thrust up till only the synclines remain. The faults along these two lines reach over the whole extent of the Blue Ridge and South mountain that has been studied, and locally the sandstone is faulted under the igneous rocks.

East of Front Royal the two faults run together, the sandstones disappear and the igneous rocks are faulted against the valley limestone. The limestone-sandstone, or western, fault, is made manifest in many places by breccias of sandstone with calcareous matter, notably northeast of Front Royal. The eastern or second main fault is for the most part inferred from the sequence, occasionally from the areal distribution of the rocks, as at Monterey and Front Royal.

On Catoctin mountain the structure is much simpler. The apparent normal sequence at Frederick is broken to the north and the strata bent into a syncline, with a probable fault at the east side. Later a post-Triassic fault occupied this line and brought the Frederick limestone down against the bottom beds of massive quartzite and black slate. Southward the synclinal axis emerges from the Jura-Trias sandstone near the Potomac for a few miles and in the middle part of Bull Run mountain in Virginia. Elsewhere the sandstones have a monoclinal dip.

While the structure of the sedimentary rocks is the first object of these pages, several facts of structure in the igneous rocks are worth stating here. These rocks are of three kinds when classed according to their original constitution, *i. e.*, diabase, granite, and quartz-porphyry. In extent the diabase is the most important and the quartz-porphyry the least. Roughly speaking, the area between the Blue Ridge line and Catoctin line is underlain by diabase, partly replaced by granite at the south, and by quartz-porphyry at the north. The granite areas occupy a triangular tract with a base of thirty miles east of Front Royal and its apex west of Frederick. The quartz-porphyry occupies two areas in the district examined by the writer, the smaller lying east and northeast of Front Royal, the larger beginning north of the latitude of Frederick and six miles north of the granite apex. Near Front Royal it occurs as a narrow strip between the diabase that forms the summit of the Blue Ridge and the Cambrian sandstones. In Maryland it lies in the form of a rude elongated cross. In Pennsylvania, according to Prof. Williams, the quartz-porphyry is as widespread as the diabase.

Upon this group the Cambrian sandstones and slates were deposited unconformably. In places the sandstone lies upon granite, in other places upon diabase, in others upon quartz-porphyry. In many localities widely scattered along the Blue Ridge, the sandstones and slates contain fragments of the igneous rocks, showing that the sandstones are later deposits.

The relations of the igneous rocks to each other are not always plain. So far as known to the writer, the granite and quartz-porphyry do not come into contact. Between the granite and diabase the contacts are common. The granite occurs in the form of large masses and eruptive tongues in the diabase and abundant evidence of its eruptive nature can be found in its irregular boundaries, offshooting tongues, and included fragments of diabase. The boundaries of granite and diabase are exceedingly complex, and areas of massive granite merge into areas of massive diabase through a multitude of interbedded tongues. These tongues vary in thickness from a few inches up to two or three miles and attain a length of six miles.

The relation of quartz-porphyry to diabase is not clear at first sight in the region under discussion. It can be inferred from several phenomena, however, with considerable surety. At several localities in Maryland are occurrences of tufaceous beds in the quartz-porphyry that indicate surface production. These beds are near the edges of the quartz-porphyry and are presumably the upper beds. Also there are frequent occurrences of banding and wavy flow structure common to surface lavas. From these facts it is probable that the quartz-porphyry was a surface flow. That being the case, the relation of diabase to quartz-porphyry is a simple one and not complex like the granite eruption. As there are only one diabase bed and one quartz-porphyry bed that can be differentiated, the diabase either follows or precedes the quartz-porphyry.

For want of bedding planes in the quartz-prophyry it is difficult to determine any structure. It may be assumed for the present that the surface of so large a flow was approximately level and that the tufaceous beds mark that surface. The present dips of that surface, therefore, represent later plication. Its general position is along low ground and drainage lines, suggesting anticlinal erosion of an underlying bed. Wherever steep slopes make the dips plain, the quartz-porphyry is the underlying bed and the tufaceous beds marking the top are next to the diabase. Several outliers of quartz-porphyry are only exposed by deep stream cuts, and several outliers of diabase cap summits in the quartz-porphyry area. The south ends of the quartz-porphyry visibly pass under the diabase. From all of these points there would seem to be no doubt that the quartz-porphyry underlies the diabase.

If this relation is accepted as true, it follows that the diabase itself was a surface flow. Internal evidence of this is wanting, for no tufaceous beds or flow structures have been observed in the diabase. Negatively, the diabase is the topmost volcanic bed and shows no eruptive contacts. It reaches continuously from Maryland ten or more miles into Pennsylvania and over half way through Virginia, with an average width of twenty miles. This extent is commensurate with the large lava flows of the present surface and is an extreme for an eruptive mass. Finally, the diabase lies on the surface of a surface flow, hence it must be a surface flow itself.

Compression has produced little change in the quartz-porphyry except the distortion of folding. Along two faults at the east base of South mountain and east of Front Royal, the quartz-porphyry has been dragged out into a lustrous mica slate of very fine texture. In some places there has also been produced a small amount of schistosity. As a rule it has suffered no change when compared with the diabase, a difference to be attributed to its simpler chemical composition (nearly pure silica) and to its greater mechanical strength.

The diabase has uniformly received a strong schistosity and rearrangement of minerals. Muscovite, biotite, chlorite, epidote, and quartz have been developed everywhere; and locally amygduloids occur with jasper, quartz and epidote. The epidote and quartz occur both in disseminated grains and in lenses attaining a thickness of four feet. Cases of unaltered diabase are very rare, but occasionally occur.

In addition to these igneous rocks, a considerable number of small dikes belonging to the Jura-Trias system were seen. These occur throughout the mountain region, but are most frequent in the granite tract.

To sum up, the sequence of the rocks in the mountain region is as follows:

SILURO-CAMBRIAN	Limestone.
CAMBRIAN	Sandstone.
"	Shale.
"	Sandstone.
"	Slate.
	Granite.
	Diabase.
	Quartz-porphyry.

Their physical history is, in brief:

Surface flow of quartz-porphyry followed after short interval by surface flow of diabase. Injection of granite into the diabase, presumably passing through the quartz-porphyry. Dynamic action and production of schistosity in diabase...Erosion.

Submergence and deposition of Palæozoic strata. Dynamic action with folding, cleavage, and elevation................Erosion.

Submergence and Jura-Trias deposition.

ON THE CLASSIFICATION OF THE DYAS, TRIAS AND JURA IN NORTH-WEST TEXAS.

By JULES MARCOU, Cambridge, Mass.

In the Second and Third *Annual Reports of the Geological Survey of Texas*, Austin, 1891-1892, Mr. W. F. Cummins has given the following classification and nomenclature for the strata in north-west Texas. He begins with the Carboniferous or Coal Measures, divided into six great formations, which he calls: Bend, Millsap, Strawn, Canyon, Cisco and Albany divisions. I shall make no remarks on the Bend, Millsap and Strawn divisions.

The Canyon division, so-called on account of its development at Canyon, in the western part of Palo Pinto county, contains a fauna entirely Carboniferous. It is a well defined formation, and easy to recognize in central and northern Texas.

The Cisco division is well exposed at the town of Cisco, on the Texas and Pacific railway. The stratigraphy, lithology and paleontology differ so much from what exist in the Canyon division, that it seems as a first great group of another stratigraphic system, or at least a passage formation between the true Carboniferous and the Dyas (Permian). In it are found a certain number of Dyassic forms, such as: *Allorisma*, *Avicula*, *Aviculopecten*, *Nucula*, etc. A careful palæontologic investigation, as well as good and minute stratigraphic observations are much wanted. For the present I am inclined to regard it as the base of the Dyassic system, and related to the group which exists on the south side of the mouth of the Platte river, at Plattsmouth City (Nebraska).

The Albany division, named for the reason that in the vicinity of Albany, in Stackelford county, the strata are well developed, correspond exactly to the Dyas of Nebraska City (Nebraska); having the same fauna, lithology and stratigraphic position.

In the *Second Annual Report, Geol. Surv. Texas*, at p. 393, there "is a complete list of fossils of the Coal Measures," in which the fossils belonging to the Cisco and Albany divisions are confounded with the fossils of the Canyon and Strawn divisions. That list needs to be revised, not only for the exact stratigraphic position of each fossil, but even also in regard to the determination of the species.

The Wichita division, well developed along the Big Wichita river, is composed of red sandstone and red clay. Quite a large number of vertebrate fossils have been found by Mr. Cummins, and described by professor E. D. Cope. Some fishes, such as: *Ceratodus*, *Ctenodus*, *Ctenacanthus*, etc., are Mesozoic forms well known in the European Dyas and Trias. Reptiles and Bachtrachians collected in Wichita division, recall also Mesozoic forms. Until now not a single locality or a minute stratigraphic position, of all those Texan fossil vertebrates has been revealed; professor Cope saying only Texas, and Mr. Cummins being as much discreet; so other geologists cannot control the exactness of the age of the strata, and the true value of Messrs. Cummins' and Cope's discoveries in comparison with the well known localities and stratigraphic positions of the fossil vertebrates of Europe. The list given by professor Cope in the *Second Ann. Rep. Geol. Surv. Texas*, pp. 416-419, is absolutely useless. If Cuvier, Agassiz and others had been so reticent and had kept secret the localities from which came the fossils they described and named, the science of *Comparative Palæontology*, and the classification of strata would not have received the great help derived from their works. The tendency of a few American vertebrate palæontologists not to divulge the localities from which they get their specimens, and to say only Texas! Wyoming! etc., is anything but creditable.

Mr. Cummins has collected a Dyassic flora in the upper portion of the Wichita division, at the head of Godwin creek, Baylor county. Professor T. C. White has recognized in it, two *Sphenophyllum*, an *Odontopteris*, a *Callipteris*, four *Callipteridium*, eight *Pecopteris*, a *Goniopteris*, and more specially a *Walchia*, so characteristic of the Dyassic flora in Europe.

It is certain that the Wichita division belongs to the Dyas (Permian), and forms the upper part of that system in Texas.

The next division, "Clear Fork beds," contains in its lower part, strata which ought to be united with the Wichita division. Such are the localities called: Camp and Godwin creeks and Military crossing in Archer and Baylor counties; in which Mr. Cummins has found a certain number of fossil invertebrates. The list published, in the *Second Ann. Rep. Geol. Surv. Texas*, p. 415, shows Mesozoic Cephalopoda such as: *Meddlicotia* and *Popanoceras*, mixed with Dyassic forms such as: *Aviculopecten*, *Gervilia*, *Clydophorus*, etc. It is a fauna related with the Russian fauna of the Artinsk beds, and may be considered as the American representative of a part of the Russian Dyas (Permian).

Some of the vertebrates determined by professor Cope have been found, according to Mr. Cummins, in the strata of the lower part of the Clear Fork division, about a little above the horizon of the fossiliferous limestone, with *Medlicottia* of the Military crossing (Baylor county). So it will be best and more logical to separate from the Clear Fork division, about 300 feet of its lowest strata, which will reduce its whole thickness of 1,975 feet, as given by Mr. Cummins, to about 1,600 feet. Then the Clear Fork division, so reduced, is a formation above the Dyas, and represents the Lower Trias or Bunter sandstone of Europe. Where I saw it, just north of the Wichita mountains, all along our road, by the 35th parallel, after passing the Cross Timbers to Rock Mary and the natural mounds, I did not find fossils; but on lithological and stratigraphic ground, I have no doubt that all the strata there are Lower Trias. In my reconnaissance of 1853, it was impossible to do more than to follow the road, with a few zig-zags, right and left, because it was a heavy marching with a military escort, with strict orders not to go outside and never to lose view of the main column.

The Double Mountain division is remarkable on account of its heavy and important dolomitic limestone, its very thick beds or lenticular masses of white gypsum and its salty clays and shales. Mr. Cummins says that he saw among the dolomites many casts of fossils, but he does not give a single determination even of family, genus or species, so we are entirely ignorant of their nature. I did not find any trace of fossils, when I crossed that formation, except near Epsom spring, before reaching Antelope hills, where I found a large fossil tree, beautifully silicified and transformed in jasper, which when polished resembles somewhat the *Pinnites fleurotii* of the Trias of the Val d'Ajol in the Vosges. I have considered that gypsum group as representing the Middle Trias or Muschelkalk of Germany; and I continue to do so, for nothing in it recalls in any way the Dyas of England, France and Saxony; it is a younger formation.

The Dockum beds or division of Mr. Cummins, was described by me as far back as 1853, as Triassic; and more, as representing the Keuper and Variagated marls of Europe. The difference between Mr. Cummins' thickness of those strata, and what I saw from Antelope hills to Rocky Dell creek and Pyramid mount (Tucumcari area), is difficult to be explained. My estimation is about 1,500 feet, when Mr. Cummins gives only from 125 feet to 400 feet, with an average of about 200 feet only. It is possible that Mr. Cummins has referred one thousand feet of the strata, between Antelope hills and Rocky Dell creek, as Dyas (Permian); and has kept for his Trias the strata from the lowest part of Rocky Dell creek to the white and yellow sandstone of the Pyramid Mount section, which according to my estimate of thickness is about 500 feet.

Now comes the Tucumcari stratigraphy, so admirably developed round the Great and Little Tucumcari mountains, Monte Revuelto and Pyramid mount. In regard to Monte Revuelto, Mr. Cummins says: "This mountain was by mistake called Big Tucumcari on the maps published by Mr. Marcou. The Monte Revuelto and not Rivuelto as it is wrongly spelled by Mr. Cummins, terminates the great mesa of the Llano Estacado, just due south of Fossil creek. It is the most prominent peak and the best landmark of the area, and it is not easy to make a mistake with. It was pointed out to us by some Mexicans traveling with our party, and by some Indians of the Pueblo of San Felipe whom we met there. The Big Tucumcari, called now only Tucumcari mount, is isolated by denudation and erosion in the great valley, called Plaza Larga by the Mexicans, north of the Llano Estacado. On Mr. Cummins' map, he took the Big Tucumcari mount for Monte Revuelto; and what he calls Big Tucumcari is truly the Little Tucumcari. As to his Little Tucumcari, it is a very small isolated hill, marked on my map, south of the true Little Tucumcari, but without any name. My geological map and the topographical map of lieutenant A. W. Whipple, of the Pacific Railroad explorations, by the 35th parallel, both surveyed and constructed in 1853, are the only exact maps ever published on the Tucumcari area, except a small sketch map, marked No. 4, in lieutenant J. H. Simpson's report of 1849, Washington, which gives also the exact position, of the Little and Big Tucumcari. The map of Mr. Cummins, in the *Third Ann. Rep. Geol. Surv. Texas*, is at variance with the three first maps published, and according to right of *pri-*

rity cannot be used for geographical names of the Tucumcari area.

In the *Marnes isisées* (variegated marls) of Plaza Larga no fossils have been found, either by Mr. Cummins or myself; but farther south-eastward, in continuity of the strata, Mr. Cummins has collected fragments of *Stegocephali, Crocodilia, Clepsysdurus* and *Zatomus.* Above the variegated marls, so easy to follow bed by bed at the Pyramid mount section, we find a series of about 200 feet of white and yellow sandstone, blue clay, calcareous sandstone and at the top a white limestone. The fossils begin to be found in the blue clay, about 30 feet thick. A bed, two inches thick, of *Gryphæa dilatata* var. *tucumcarii*, packed close together, is found at half a foot from the base; and more of those *Gryphæa tucumcarii* can be collected higher up, in the whole group of blue clay, with an *Ostrea* of the *Ostrea marshii* form. Those two fossils are characteristic Jurassic species, and indicate that the age of the blue clay is Oxfordian.

Mr. Cummins accepts the *Gryphæa dilatata* var. *tucumcarii* as a good species distinct of the *Gryphæa pitcheri* of the Texas Neocomian; but it is his only concession. In a special chapter, entitled: "Notes on the geology of the country west of the Plains —Tucumcari, New Mexico," pp. 201-210, in the *Third Ann. Rep. Geol. Surv. Texas,* Mr. Cummins contests the exactness of my conclusion in regard to the Jurassic age, and he refers the Tucumcari beds to the Cretaceous, and in that system to the Washita division; that is to say, to the upper part of the Lower Cretaceous, above the Trinity division, and even above the Commanche Peak and Fredericksburg division.

Lithology.—Mr. Cummins has a long and useless dissertation on lithology, saying that I committed an error, to call "Calcareous sandstone or sandy limestone" the strata above the blue clay with *Gryphæa tucumcarii,* which he calls, also, like me, "Calcareous sandstone." It is exactly the same definition, and even the same name. In my wood-cut section of Pyramid Mount (see THE AMERICAN GEOLOGIST, Oct. 1889, p. 162), for brevity of the table of explanation of the letters used to designate each bed, I used only "Yellow limestone," but in the description of the strata I call them "Yellowish siliceous limestone," and in Vol. III, *Pacific Railroad Explorations,* "Calcareous sandstone." So there is no ground whatever for a discussion. I have called the beds in 1853, "Calcareous sandstone," and Mr. Cummins calls the same beds in 1891, also, "Calcareous sandstone."

Palæontology.—"The following is a list of the fossils collected by me (Mr. Cummins) from the Tucumcari beds in the vicinity of Tucumcari and Pyramid mountains:"

Gryphæa dilatata var. tucumcari, Marcou.
Ostrea marshii, as determined by Marcou.
Gryphæa pitcheri Morton.
Exogyra texana Rom.
Ostrea quadriplicata Shumard.
Trigonia emoryi Con.
Cardium hillanum Son.
Cytherea leonensis Con.
Turritella seriatim granulata Rom.
Pinna sp.
Ammonites.
Pecten.

Everyone who is familiar with assimilation of strata and parallelism of formations, always takes special care to give proofs of identity of fossils, by means of good figures and descriptions of species. Here not a single fossil pretended to be identical with fossils of the Washita division, is either figured or described. Mr. Cummins contents himself in saying: "I believe if Marcou had seen the fossils I have collected he would not have hesitated to place the Tucumcari beds in the Cretaceous." I shall ask simply, why Mr. Cummins did not send me his fossils to look at?

The Ammonites, which are always among the most important fossils for determination of age of the strata, are not even hinted at; simply saying *Ammonites.*

Professor A. Hyatt made an extended and very minute exploration of the Tucumcari area in 1889. He collected numerous and important series of a quantity of fossils—at least sixty species—and he asked me to look over his collection with him. I did not see in it a single Cretaceous fossil; no *Gryphæa pitcheri*, no *Exogyra texana*, etc. Professor Hyatt is justly considered as the best specialist, on this side of the Atlantic, for fossil cephalopods; and he has already worked out for the Geological Survey of Texas, the "Carboniferous cephalopods" published in the *Second Ann. Rep.*, and is now engaged on the Nautilidæ of Texas, also for the Geological Survey. Why did not Mr. Cummins send his collection to professor Hyatt, at Cambridge, to compare what he got with the fine specimens of Mr. Hyatt?

As it is, the list of fossils published by Mr. Cummins cannot be used. I shall only say, that it is simply impossible to find together in the same bed the *Gryphæa dilatata* var. *tucumcari*, with the *Gryphæa pitcheri* and the *Exogyra texana*. Either the fossils determined by Mr. Cummins are incorrectly referred to species entirely different, or by some accident Mr. Cummins' specimens have been carelessly packed up and the labels have become somewhat mixed or changed from one packet to another.

Mr. Cummins insists with great force on his discovery in the top bed of the Tucumcari mountain, of a fragmentary leaf of a dicotyledonous plant called *Sterculia drakei*, which he describes and figures at p. 210. Until now, he says, no angiospermous leaves have been found in older strata than the Cretaceous, and "a single specimen in certain cases is sufficient to definitely determine the age to which the strata belong."

Fossil leaves of Angiosperms have been found, some time ago, round Fredericksburg, Virginia, in strata called the Potomac formation, which is regarded by some geologists as belonging to the lowest beds of the Wealden, and by some others as old as the Purbeck formation or upper Jura of England. A leaf resembling in the outline a leaf of sassafras has been found in the Potomac formation of Virginia, similar to the leaf found at the Tucumcari. So there is nothing very new in the discovery of a leaf of dicotyledonous plant in the Jurassic bed of the Tucumcari mountain.

I have showed before (THE AMERICAN GEOLOGIST, Dec., 1889: "Jura, Neocomian and Chalk of Arkansas," pp. 357-367) that the Trinity beds of Arkansas contain a fauna entirely Jurassic, and that they belong to the Jura system. It seems, according to the observations of Mr. Robert T. Hill, that the upper part of the Tucumcari strata, above the horizon of the *Gryphæa tucumcari*, is related and of the same age as the Trinity beds.

In résumé, the supposed Cretaceous age of the Tucumcari strata is an error; not so great as the one of Messrs. James Hall, Shumard, Meek and Newberry, who synchronized them with the Dakota division of the upper Cretaceous, but is no less a grave one, for it displaces a whole system of rocks from its position just above the Trias and below the true Cretaceous Neocomian of Texas, and puts it far up, as the upper portion of the Lower Cretaceous, or Washita division.

Another grave error is the reduction of the Texan Trias to the upper 200 feet of that system, which has truly in Texas a thickness of no less than 5,000 feet; and to refer to the Dyas or Permian, not only the Lower and Middle Texan Trias, but even two-thirds of the Upper Trias, reducing the great Texan Trias to an insignificant system; and at the same time giving to the Texas Dyas an importance absolutely imaginary, and out of all proportion to its value and position in American stratigraphy. Besides Mr. Cummins has increased also the already very great formation of the Coal Measures or Carboniferous, in placing in it the Lower Dyas of Nebraska City and Plattemouth, Nebraska, which he calls Albany and Cisco divisions of the Coal Measures.

As the Geological Survey of Texas has begun to publish geological maps of great area, in the *Third Annual Report*, it is important to signalize to its director the difference of opinions held by other observers than his own assistants in the survey, on questions which involve great scientific responsibilities, not only for Texas, but also for American geology.

Here is the detailed table showing the order of succession and classification of northwest Texas, the Indian Territory and New Mexico by Mr. Cummins, in comparison with the classification I have given as far back as 1853, and which has been repeated in detail in THE AMERICAN GEOLOGIST, September, 1889, pp. 156-157.

Mr. Cummins' classification in North-west Texas and New Mexico, 1890-1891.	Mr. Marcou's Classification. 1853.
	CRETACEOUS. *Gryphæa pitcheri* limestone of Comet creek, or Neocomian. Thickness, 5 feet.
	Break. Unconformity.
TERTIARY.—No. 2. White clayey limestone. 20 feet.—G.	
CRETACEOUS. Washita division, numbered 3, 4, 5 and 6, and corresponding to F, E, D, and C, of Marcou's section, at the Tucumcari area.—375 feet.	JURASSIC SYSTEM. Section of Pyramid mount, Tucumcari. No Tertiary.—Jurassic rocks numbered with letters G, F, E, D, C and B. The divisions G and F belong to the Upper Jura; E represents the Oxfordian.—195 feet.

TRIASSIC.	Concordance of stratification. Dockum division.—400 feet.	TRIASSIC SYSTEM. KEUPER.	Concordance of stratification. Variegated marls.—500 feet.
PERMIAN.	Double Mountain division. Thickness, 2075 feet.	TRIASSIC SYSTEM. KEUPER.	Sandstone, dolomite and red clay; extending from Antelope hills to Rocky Dell creek.—1000 feet.
PERMIAN.		TRIASSIC SYSTEM. MIDDLE TRIAS.	Red marls inclosing gypsum, salt, clay and dolomite, extending from Natural Mounds to Antelope hills. —1500 feet.
PERMIAN.	Clear Fork division.—1875 feet. *Nota bene.*—At the base of the division—about the first 300 feet—invertebrate fossils have been found at Military crossing and Godwin creek (Baylor Co.), and at Camp creek (Archer Co.). A few vertebrates have been found also scattered at about the same lower horizon.	TRIASSIC SYSTEM. BUNTER SANDSTEIN.	Vermilion marls and clays, interstratified with beds of red marly sandstone, with green spots; extending from Cross Timbers to Rock Mary and Natural Mounds. —2000 feet.
PERMIAN.	Wichita division.—1800 feet. *Nota bene.*—In the upper part, at the head of Godwin creek, a Dyassic flora with *Walchia* has been found, with vertebrate fossils such as: reptiles, batrachians and fishes.	DYASSIC SYSTEM.	*Nota bene.*—This formation embraces the lower portion of the Clear Fork division—about 300 feet—and the Wichita, Albany and Cisco divisions of Mr. Cummins. Red and blue clay with conglomerate; extending from Topofki creek to Cross Timbers, west of old Fort Arbuckle or Beaversville.—1000 feet.
COAL MEASURES.	Albany division.—1180 feet. With the Dyassic fauna of Nebraska City.	DYASSIC SYSTEM.	
COAL MEASURES.	Cisco division.—840 feet. Dyassic mixed with Carboniferous fossils.	DYASSIC SYSTEM.	Break. Unconformity.
COAL MEASURES.	Canyon division.—930 feet. With a Carboniferous fauna.	CARBONIFEROUS SYSTEM.	Limestone of Delaware Ridge, with a Carboniferous fauna.

THE AREAL WORK OF THE U. S. GEOLOGICAL SURVEY.*

By W. J. McGEE, Washington.

When the U. S. Geological Survey began its work some 13 years ago, only a small portion of the public domain was mapped out, so that the first thing to be done was to prepare a topographical map. It was not considered then nor is it considered now, necessary to prepare a detailed map; all that was and is desired is a map giving the main landmarks and the contour lines, surveyed and drawn with just sufficient accuracy for the scale of the map and no more. It was at first decided to use the scale of four miles to the inch throughout most of the domain and employ the scales of two miles and one mile to the inch in more important centers. However, the methods of survey have been so much improved since then, and the cost per mile so much reduced in con-

* Abstract of a paper read before the American Institute of Mining Engineers, at the Reading Meeting.

sequence, that it has been found consistent with economy to abandon the four-mile-to-the-inch scale, and subsequently the two-mile-to-the-inch scale was abandoned also. This adoption of the one-mile-to-the-inch scale was also rendered necessary, as it became evident that the requirements of geologists would not be met satisfactorily by the smaller scales. The total area surveyed topographically to date is 537,000 square miles, distributed over 42 states and territories. Four states, viz., Connecticut, Massachusetts, New Jersey and Rhode Island, together with the District of Columbia, have been completed. Each sheet of the maps is about 15×18 in. and the side of the one-mile-to-the-inch map represents 15 minutes of latitude. The sheets are engraved on copper and are printed from stone transfers. Each sheet is printed from three plates, giving respectively the hydrography in blue, the altitudes between contour lines in shades of brown, and the topography in black. Altogether 615 sheets are now printed in the different scales out of the 694 sheets surveyed for. No legal provision has yet been made for the public sale of these maps.

No system has ever yet been uniformly adopted among civilized countries for representing the geological structure and characteristics in maps. Most geological authorities at present adopt some arbitrary system of coloring according to their own taste and fancy, so that the art of geological mapping may be said to be only in an experimental stage as yet The system adopted by the U. S. Geological Survey is novel, and is thought to meet the requirements of engineers, miners, etc., in a better way than any other method yet proposed or tried. The system provides for the separation of rock formations into four classes, viz.: 1. Fossiliferous or fragmental; 2, volcanic; 3, granitoidal and schistoidal, and 4, superficial. These classes of rocks are represented by ground colors and pattern overprints in such a manner that the entire range of available colors may be used for each. The fragmental rocks are represented by the primary colors in orderly arrangement, each color indicating an age-group (Carboniferous, Silurian, etc.). These colors are used as uniform ground tints, and overprints in line patterns represent the distinct formations of which the group is made up. The volcanic rocks are represented by angular figures either on a white ground or over a ground tint representing an age-group. The crystalline rocks are similarly represented by hachures disposed either irregularly or in such a manner as to indicate structure. The superficial deposits are represented by round figures in such a manner that they may be mapped in their normal relation, overlying the older rocks, on the sheets showing the underlying formations. The general system provides for the representation of the geology on the topographical maps. The atlas sheets are colored in manuscript by the geologists in the field and the geological symbols are afterward engraved on zinc. In order to make these sheets available for all uses, provision has been made for printing each sheet in portfolio form, supplemented by as many different impressions of the same map as may be required. Thus the portfolio will usually include a topographic sheet without geological symbols; a geological sheet showing only the age-groups and formations; a structure sheet in which sections drawn to scale are printed on a sheet showing the groups and formation boundaries; sometimes a sheet of columnar sections showing the structure in greater detail; in some cases a sheet showing the superficial deposits only; and when the occasion requires, a sheet of mineral resources, showing the location of mines, quarries, coke ovens, smelters and furnaces as well as mineral areas.

These geological surveys consume much time. Moreover, a variety of circumstances have combined to delay the completion of the surveys except in special districts, such as the Lake Superior iron region, the quicksilver and gold regions of California, the phosphate belt of Florida, the Eureka and Virginia City districts in Nevada, and some mining areas in Colorado.

Final geological surveys of greater or less extent have been executed in 32 states and territories. These surveys cover an area of 117,000 square miles, and are in part represented on 100 regular atlas sheets and a large number of special maps.

The cost of the topographical surveys has varied with the scale and other conditions from less than \$1 to over \$5 per square mile. The average cost of the survey, including drawing, has been \$3 per square mile on the one-mile-to-the-inch scale and the total cost since the first has been about \$4 per square mile. The cost of the geological survey has varied between much wider limits. In fairly representative districts the cost has averaged \$5 to \$6 per square mile. The average cost from the beginning has averaged \$8 per square mile, but this cost includes preliminary expenditure on instruments, books, laboratories, etc.

THE PRESENT BASAL LINE OF DELIMITATION OF THE CARBONIFEROUS IN NORTHEASTERN MISSOURI.*

By CHARLES ROLLIN KEYES, Des Moines.

Although for many years past the Kinderhook beds have been regarded as the basal part of the Lower Carboniferous, or Mississippian series, in the upper Mississippi valley a decided Devonian facies of the contained fossils has always been observed. This particular faunal aspect has occasioned much comment and has attracted wide notice.

So much were some of the earlier geologists impressed with this character of the organic remains that they hesitated but little in referring the beds in question to the upper Devonian (Chemung).

The best exposures of Kinderhook rocks are found along the Mississippi river at Burlington, Iowa, Kinderhook, Ill., Hannibal and Louisiana, Missouri. At all of these places the lithological characters are practically the same, except perhaps towards the more northern limit of their exposed range, where the upper part is changed somewhat and the lower portion does not rise above the water level.

At Louisiana the exposures are perhaps more open to observation than elsewhere; though for seventy miles along the river the outcrop is practically continuous.

The vertical section at the place just mentioned is as follows:

	Ft.	in.
16. Brown and white, compact, encrinital limestone thinly bedded, with some chert	75	
15. White, encrinital limestone very heavily bedded	12	
14. Coarse-grained encrinital limestone, very heavily bedded	20	
13. Massive, white encrinital limestone, coarse-grained with abundant white chert nodules and nodular bands	11	
12. Brown encrinital limestone, compact and heavily bedded, somewhat earthly in places	15	
11. Compact, fine-grained buff limestone with few or no partings	15	
10. Sandy shales, brownish, forming soft friable sandstone locally	12	
9. Greenish, clayey shales	70	
8. Thinly bedded, compact limestone, fine-grained, with conchoidal fracture, in layers 4 to 6 inches in thickness, like lithographic stone in texture and appearance	50	

*Published by permission of Mr. Arthur Winslow, director of the Geological Survey of Missouri, from work prosecuted during the years 1891-2.

7. Sandy clay shale (2 to 4 inches)		3
6. Drab or greenish clayey shale...	2	
5. Black, fissile clay shale	4	
4. Buff, magnesian limestone, very heavily bedded......	10	
3. Compact, white oolite	5	
2. Blue clay-shale, with thin bands of impure limestone	60	
1. Heavily bedded limestone, exposed..................	5	

No. 1 is the Trenton limestone; 2 the Hudson River shales; 3 and 4 probably represent the Niagara limestone; the first increasing rapidly in thickness southward, and in a distance of 20 miles reaches a vertical measurement of 30 to 40 feet. 5 and 6 are probably Devonian, equivalent to the "black shale" of adjoining states. Number 7 is a thin seam 2 to 4 inches in thickness and highly fossiliferous. With few exceptions the "lithographic" fossils come from this layer. It probably belongs more properly with beds 5 to 6. Apparently the organic remains are nearly all identical with forms from the Hamilton rocks farther northward. Should the union of this thin highly fossiliferous seam to the underlying shales be more in harmony with the real relation of the faunas of the respective beds, as now seems likely, than with the faunas above, it would remove to a great extent the present Devonian facies from the lithographic (Louisiana) limestone. 8 is the Louisiana limestone, a compact, rather thinly bedded rock, breaking with a conchoidal fracture. It is very poor in fossils. Numbers 9 and 10 are the Hannibal shales. 11. the Chouteau limestone, with a few fossils. Number 12 is the Burlington limestone, with the characteristic basal faunas of the Burlington. 13 is also the lower Burlington, carrying considerable chert, and containing the most prolific fauna in the section. 14, 15 and 16 belong to the Burlington limestone; the upper portion containing the typical fauna distinctive of the upper division.

Owen*, who was the first to give attention to the geological details of the rocks as exposed along the "Father of Waters" above the mouth of the Missouri, limited the term "Subcarboniferous," which hitherto has long been applied to all the strata below the Coal Measures as far down as the Hudson River shales, to what is now known as the Lower Carboniferous, or Mississippian series. The Louisiana or "Lithographic limestone" was not included; for his "Argillaceous Marlites" seem to have been regarded as the basal member.

*U. S. Geol. Sur. Wisconsin, Iowa, and Minnesota, p. 92. (1852.)

Swallow*, Hall†, and White‡, who are all well acquainted with the sections and their fossils, correlated the beds immediately below the Burlington limestone with the Chemung (Devonian). In northeastern Missouri and adjoining portions of Iowa and Illinois, the "Chemung" includes the Chouteau limestone, Vermicular shales and Lithographic limestone.

Hall having studied more particularly in Iowa, erroneously regarded certain sandy shales, or yellow sandstones, just below the great limestone at Burlington, identical in age with a lithologically similar rock 50 miles to the northward, at the mouth of the Pine creek, Muscatine county. The latter has recently been shown by Calvin§ to belong to the Hamilton group as known in Iowa. Consequently Hall having investigated the northern locality more thoroughly, perhaps, very naturally came to the conclusion that the entire formation under consideration, as he understood it, was actually Devonian. But, as already shown, the rocks of the two places are widely separated in point of time.

Meek and Worthen‖, who had considered chiefly the fossils in the upper part of the so-called "Chemung," both at Burlington, Iowa, and at Kinderhook, Illinois, a few miles from Hannibal, Missouri, regarded the fauna more closely related to the Carboniferous than to the Devonian. Since the publication of these views writers upon the subject have accepted them and they have been adopted in the geological reports of Illinois, Missouri and Iowa.

By reference to the vertical section already given it will be seen that the commonly known Kinderhook of this region is a threefold division, the upper and lower being limestones and the median one a clayey or sandy shale. At Burlington the fossils heretofore noted have been found only in the upper portion of the formation, though recently an extensive and interesting fauna has been discovered in the clayey portion much lower down. Here the lower calcareous member is not exposed. At Louisiana and the vicinity the median member is practically unfossiliferous; as is also the lower, except at the very base.

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*Geol. Sur. Missouri, Ann. Rep., p. 101. (1855.)

†Geol. Iowa, Vol. I, p. 90. (1858.)

‡Proc. Boston Soc. Nat. Hist., Vol. VIII, p. 289. (1862.)

§AMERICAN GEOLOGIST, Vol. III, p. 25. (1889.)

‖Am. Jour. Sci., (2), Vol. XXXII, p. 167. (1866.)

It will be recalled that Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarkesville principally, were the leading localities for a large proportion of the "Kinderhook" fossils originally described by Shumard, Hall, White and Winchell. And it has been noted that most of these fossils have a very decided Devonian aspect; that they give a peculiar tone to the fauna of these beds.

Heretofore little mention has been made concerning the exact horizon of the fossils in question, since reference to the "lithographic" limestone or "Kinderhook" beds has been considered sufficient. Lately, however, extensive collections of fossils have been made at all three of these places just mentioned as well as many intervening and neighboring exposures. Everywhere the "lithographic," or Louisiana, limestone has been found to be practically devoid of organic remains except an occasional form in the thin sand partings above the bottom layer which is less than one foot in thickness.

At the very base of the limestone is a thin seam of buff, sandy shale seldom over three or four inches in thickness (number 7 of section).

This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Sprifera hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of western Hamilton. The sandy seam is underlaid by six feet of dark argillaceous shale which has been regarded as part of the Devonian "black shale" of the Mississippi basin. This in turn rests upon 15 feet or more of buff, magnesian limestone and oolite of Niagara age probably.

Lithologically the thin sandy layer is more closely related to the underlying shales than to the overlying limestone. Faunally it has very much closer affinities with the western Hamilton (Devonian) than with the Kinderhook (lower Carboniferous).

In Iowa the "Devonian aspect" of the Kinderhook fossils has disappeared largely, since Calvin's recent discovery that the "Chemung" sandstones of Pine creek, in Muscatine county, are in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the Carboniferous is lost from view completely by eliminating the species found in the thin sandy seam at the base of the Louisiana, or lithographic, limestone. Thus the faunas of the Devonian and Carboniferous of the upper Mississippi valley become more sharply contrasted than ever. And the apparent mingling of faunas from the two geological systems manifestly is due to erroneous assumptions rather than detailed field evidence.

Depriving the "Lithographic" limestone, which attains a thickness of more than 60 feet at Louisiana, in Pike county, Missouri, almost entirely of the extensive fauna commonly ascribed to it, and which has been seen comes from a thin seam lying below the calcareous layers, its geologic age becomes a problem yet to be solved. The few fossils known from the limestone itself have been heretofore rarely met with. But until abundant evidence to this effect is found it seems advisable to still consider the Louisiana (Lithographic) limestone in this region as the basal member of the Carboniferous.

It appears very probable that a marked unconformity exists between the Carboniferous and Devonian rocks of the area under consideration, instead of a regular sequence of strata as has been supposed usually. The proofs of this statement, however, are not such at present as to warrant a definite formulation of the evidence, yet many facts recently observed point strongly towards this conclusion; while the sharply contrasted faunal peculiarities are in themselves very suggestive, and very remarkable.

EDITORIAL COMMENT.

The First Decad of the Geologist.

With this month closes the tenth volume of The American Geologist. It may not be unwholesome to revert briefly to the past five years. That time is too short an interval to warrant the expectation of great results, or to span any of the great epochs which mark revolutions in science. There is of course in the history of every revolution, whether in politics or in science, a seeding time and a reaping time. The changes in geologic science, however, have always been so gradual, and spread over so many countries, that the participants have rarely realized whether they were sowing or reaping; and it has required the observer of a later generation, who could gather up the elements of the science of the past and analyze them, to point out the seed and the fruit it may have produced. While the science of geology can claim hardly more than a century, though it doubtless existed long in an embryonic state, it has witnessed some marked periods of progress. Epoch-marking men can be pointed out all through its history. Such were Hutton, Cuvier, Darwin and Louis Agassiz. Such were Amos Eaton, Ebenezer Emmons and Leo Lesquereux. Yet during their lives they were not known as such. They had their opponents and difficulties, and their followers only could fairly appreciate their labors.

The American Geologist cannot distinctively lay claim to the credit of sowing seed, nor reaping fruit. It doubtless shares, however, in both. No such publication can be said to exist without some influence. The future only will reveal what may be the effect of its influence on American geology. Inside of the cases of its ten tomes, which have been sent regularly to all parts of the world, are contained the thoughts of numerous American geologists, on many of the obtrusive problems of the science as they have come before students in America. Besides the "Reviews," "Correspondence" and "Personal and Scientific News," those volumes contain 246 contributed articles, not written by its editors, 108 editorial articles, and 56 articles of "editorial comment." There have been described, within these ten volumes, 23 new genera and 117 new species of fossil forms. Microscopic petrography and general paleontology and stratigraphy have been fully represented in its pages. While necessarily questions of general geology have had a large share in the pages of the Geologist, yet the relations of geology to education and to ethical training, as well as to the operations of the miner and the surveyor have frequently been discussed. Astronomers, chemists and mineralogists have alike found information and valuable research by perusing its monthly issues.

Notwithstanding this, the Geologist has not accomplished, in its full measure, as intended at the outset, and as foreshadowed in the "Introductory," at the opening of volume 1, all that its editors have desired. It is natural for man to plan and adopt as nearly as possible a model design; it is, alas, also natural that its accomplishments should fall short of the perfect model. The editors of the Geologist are no exception to that order of nature, and they admit that their efforts have not been sufficient as yet to carry out all that was promised in the "Introductory." Perhaps they will be able to approach nearer to the achievement of their highest hopes during the next five years.

Five years ago, in the midst of a general feeling of disquiet among the geologists of the country, seven men boldly took the initiative in the establishment of an American journal which should give expression as well to the "feeblest whispers" as the "loudest thunder" of geological thought in America. Six of these discharged all their promises, and, except for the intervention of the pale messenger, six of them would still be found steadfast in their places. This board conducted the GEOLOGIST through two years. Five remain of that seven, but their burdens have been lightened by the addition of seven others to their ranks.

On this accession to the editorial board, making twelve, it was planned, at first, that each editor should be responsible for the issue of one number, in alphabetical rotation. This has been in a measure carried out, but it was found shortly that the labors of the respective monthly editors would have to be mixed in the monthly issues. The editors are scattered from the Atlantic to the Pacific, and from the lakes to the gulf, and with all possible precaution and dispatch the timely succession of contributions could not be kept in orderly routine. Therefore there is no way of indicating the amount of work done by the individual editors, nor of establishing the authorship of the anonymous articles, except that each contributor knows his own.

It has been the practice, from the first, to maintain an anonymous editorial department, and also to print all reviews anonymously. The unpleasant truth must sometimes be told, and it is more likely to be told and told correctly under the shield of an anonymous journal than when its relator is compelled to carry the brunt of all its consequences. Therefore the editors have had equal and untramelled freedom, as individual editors, to write whatever they chose. Sometimes they have found themselves at variance on views expressed, and they have had the privilege not only as individuals to disown what they did not approve, privately, whenever they have been disposed, but even to criticise the GEOLOGIST publicly in their own name, or to write counter editorials in rebuttal of other views. The GEOLOGIST is therefore no "composite photograph" of twelve, without character and complexion, and destitute of all dominant traits, but is instead a lively succession of single photographs each one of which shows its strong traits. The editors understand this and they wish the reader also to bear it in mind. While the GEOLOGIST as a journal, is responsible for all that is said between its covers, the separate editors must be considered responsible in the first instance only for what they may contribute; but, secondly, they share in the joint responsibility of the anonymous articles. The former they cannot repudiate, but the latter they may disclaim in any way they choose. It is manifest that this secures for the journal the largest possible result from a composite editorship, and yet yields to every editor the right of such individual personality as he may choose to assert irrespective of his associates.

The editors wish to take this opportunity to again express their obligations to the geologists of America. Without their co-operation it were vain to attempt to sustain such a magazine in America. The editors feel encouraged, and even flattered, by the cordiality and generosity with which the journal has been received. While it has not yet reached a self-sustaining financial basis, it has come very near to it, and the editors are confident that in the near future with a continuance of the favors of the past it will pass that mark.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Man and the Glacial Period. BY G. FREDERICK WRIGHT. With an appendix on *Tertiary Man,* by Prof. HENRY W. HAYNES, pp. 385, with three folded maps, and 108 figures in the text. New York: D. Appleton & Co. (No. 69, International Scientific series.)

This work is partly an abridgment and partly an extension of the author's previous larger volume, "The Ice Age in North America." Glaciers and ice-sheets now existing are described in the first three chapters, special attention being given to the Muir and Malaspina glaciers in Alaska and the ice-sheet and glaciers of Greenland. The next two chapters are devoted to the Pleistocene glaciation of North America, its striæ, till, drumlins, terminal moraines, kames, and valley drift and terraces. The sixth chapter treats of the ancient glaciers of the Alps and other mountains in the eastern hemisphere and the ice-sheets and glacial drift of northwestern Europe, including a very interesting description of the drift in Great Britain by Mr. Percy F. Kendall, with an excellent contour map of the British Isles.

In the seventh chapter the changes of drainage produced by the ice-sheets are described, with the formation of a glacial lake in the Ohio valley, of the much enlarged Laurentian lakes when the receding ice was a barrier preventing their present northeastward outflow, of lake Agassiz in the valley of the Red river of the North and basin of lake Winnipeg, and of the Quaternary lakes Bonneville and Lahontan in the arid Great Basin of interior drainage. For the parallel roads of Glen Roy in Scotland the old explanation is given, ascribing them to obstruction by a local glacier, instead of which Jamieson has shown that the glacial lake of Glen Roy was pent up by the departing Scottish ice-sheet.

The evidences of man's existence during the glacial period both in Europe and North America are the subject of the eighth chapter. For this continent the author should have added, besides the many localities which he cites where stone implements have been found in river gravels belonging to the ice age, the three discoveries showing man to have been contemporaneous with the great Pleistocene lakes, namely, the charred sticks, ashes and stones placed to form a rude hearth, found at a depth of about 18 feet under the ridge of beach gravel on the shore of the glacial lake, Iroquois, in Gaines township, N. Y., which Gilbert refers to the time of discharge of this lake through the Mohawk and Hudson rivers; the chipped fragments of quartzite found by Tyrrell in a beach of lake Agassiz; and the obsidian spear-head discovered by McGee in the sediment of lake Lahontan.

Professor Wright discusses the cause and date of the glacial period in the two remaining chapters. Concerning the cause, he agrees with Upham and Le Conte that it was probably the great altitude to which the glaciated countries had been uplifted during the closing stage of the Tertiary era and beginning of the Quaternary, shown by fjords and submarine valleys to have been generally 3,000 feet or more above their present hight; and concerning the length of the Postglacial or Recent period, his observations accord with those of N. H. Winchell, Gilbert, Andrews, and others, that probably only about 7,000 to 10,000 years have elapsed since Canada and the northern United States were uncovered from their ice-sheet. The length of the Glacial period is believed, as by Prestwich, to have been probably no more than 30,000 or 40,000 years. Only one epoch of Pleistocene glaciation is admitted by the author; and the supposed interglacial forest beds and other fossiliferous beds between deposits of till are attributed to moderate recessions and re-advances of the ice-border. This interpretation and some others of the author's conclusions, especially those relating to the cause of the Ice age and its date and duration, will doubtless be topics of much further debate by glacialists, as indeed they have been already during many years, before unanimity of opinions will be reached.

Professor Haynes, in an appendix of ten pages, reviews the evidences which by some archaeologists have been thought to indicate man's existence in the Pliocene and Miocene periods, and concludes that they are wholly unreliable. The antiquity of our race, so far as it is demonstrated by geology, extends back, therefore, according to these authors, probably not much more than 20,000 or 30,000 years, for the earliest discovered traces of paleolithic man seem referable to the time of maximum extension of the ice-sheets and their ensuing stages of retreat.

Mammalia from Mongolia. By R. Lydekker, Esq. Contributed to the Records of the Geological survey of India (vol. xxiv, pt. 4, pp. 207-11). Fourteen specimens representing several species (*Hyæna Equus, Gazella*) are described, and according to the author, great interest is attached to these species for the reason that they carry the Pliocene mammalian fauna to a more northern district of China, than has hitherto been reported, and that they indicate two new Indian Siwalik species in Chinese territory. Three figures of teeth in the text.

LIST OF RECENT PUBLICATIONS.

I. Government and State Reports.

Geological Survey of Texas, Bulletin No. 1. Artesian water on the Llano Estacado, Dr. Geo. G. Shumard; also Report and analyses of Texas Sumach (Rhus copallina), by George H. Kalteyer. Austin, 1892, pp. 19.

Sketch of the Geology of Alabama. E. A. Smith, state geologist, octavo, pp. 36.

First Report of the Bureau of Mines, to the Legislature of Ontario, Archibald Blue, Toronto, 1892, pp. 253. One geological map.

U. S. Dept. of Agriculture, Relations of Soil to Climate. E. W. Hilgard, Washington, 1892, pp. 59.

U. S. Geol. Survey, Mineral Resources of the United States, calendar years 1889 and 1890. David T. Day. Octavo, pp. 671.

II. Proceedings of Scientific Societies.

Acad. Nat. Sci., Philadelphia, Part ii, April-October, contains: Mineral localities of Philadelphia and vicinity, Rand, Jefferies and Cardeza; The Fauna of the Blanco beds of Texas, E. D. Cope; A revision of the North American Creodonta, with notes on some genera which have been referred to that group. W. B. Scott.

Royal Society of Canada, Transactions, vol. IX, Sec. IV, contains: Parka decipiens. Notes on specimens from the collections of James Reid, Sir Wm. Dawson and Prof. Penhallow [Reviewed in the GEOLOGIST, vol, IX, p. 341]; The gold-bearing rocks of New Brunswick, and the possible discovery of remunerative gold deposits in that province, L. W. Bailey; Two species of trees from the Post-Glacial of Illinois, D. P. Penhallow; Illustrations of the fauna of the St. John group, No. VI, G. F. Matthew; On the geology of the St. Clair tunnel, Frank D. Adams; The Orthoceratidæ of the Trenton limestone of the Winnipeg basin, J. F. Whiteaves, [Reviewed in the GEOLOGIST, vol. X, p. 124]; Deep wells in Manitoba, J. B. Tyrrell; On the geology of part of the Province of Quebec, R. W. Ells; On the mode of occurrence of remains of land animals in erect trees at the South Joggins, Nova Scotia, J. W. Dawson.

Annales de la Soc. Geol. de Belgique, Tome XIX, 2 me livraison, contains: Contribution à l' étude du frasnien, X. Stainier; Observations sur la correlation des diverses bandes considérées comme frasniennes par M. X. Stainer, par G. Dewalque; Quelques observations relatives au devonien du bassin de Namur, G. Malaise; De la formation des dépôts de phosphate de chaux dans la province de Liége, Cam. Gillet; Sur une analogie de formation d'une variété de phosphate de chaux de Hesbaye et des phosphates de Curacao et de la Floride, M. Lohest; Distribution d'eau de Bruxelles, par Ed.-G. Detienne.

Bulletin de la Soc. Geol. de France, t. XIX, No. 13, July, 1892, contains: Note sur la succession des zones du terrain crétacé du Beausset et sur leur comparaison avec celles des Martigues. A. Toucas; Note sur la serie saumâtre de Fuvean et de Rognac, Ph. Matheson; Note sur le gisement du Rouve et sur l' âge des couches cretacées supérieures du Beausset, M. Peron; Note sur la bande d' affraissements de Chibron, M. Bertrand; Sur l' allure tourmentée des plis isoclinaux dans les montagues de la Savoie, M. Kilian; Observations sur l' âge des plis de la Provence, M. Collot; Sur le Bajocian du Var, M. Kilian; Note sur les zones de plissements de Salernes et d'Aups, M. Zürcher; Observations sur les couches fluvio-la-custres à Lychnus et l' Urgoaptien d' Orgon (Bouches-du-Rhône), par Edm. Pellat.

Jahres-Bericht d. Naturforsch, Gesell. Graubündens, XXXV, (1890-91). Chur, 1892, contains: Geologische Bau des Rhälikongebirges, Chr. Tarnutzer.

Mittheilungen des Naturf. Gessell, in Bern, 1891 (1892), Nos. 1265-1278, contains: Beiträge zur interglacialzeit auf der Südseite der Alpen, A. Baltzer; Der Loess des st, gallischen Rheinthals, A. Baltzer; Zur herkunft der bernischen bunten Nagel-fluh, A. Baltzer.

Annalen d. K. K. Naturhist, Hofmseums,Wien, 1892, Band VII, No. 1 u. 2, contains: Die Gastropoden des Schichten von St. Cassian der südalpinen Trias, II. Theil, Ernst Kittl.

Abhand. d. Gross. Hess. Geol. Land-Anstalt, zu Darnnstadt, Band II, Heft 2, comprises: Die alten Neckarbetten in der Rheinebene, von A. Mangold.

Ueber die basaltischen Kralerbildungen nördlich und nordöstlich von Giessen, A. Streng, (XXIX, Ber. d. Oberhess. Gessell, Nat. u. Heilkunde, zu Giessen). Eine Reise in das Land der Mormonen, A. Strong (Iden).

Geologische und geographische Experimente, von Ed. Reyer (Wein). I u. II Hefte, Leipzig, 1892.

III.—Papers in Scientific Journals.

Can. Record of Science, Vol. v, No. 3, contains: Thomas Sterry Hunt, J. W. Dawson, (with a portrait); The Utica terrane in Canada, H. M. Ami.

No. 4 contains: Description of a new genus and species of phyllocarid Crustacea from the middle Cambrian of Mt. Stephen, B. C., J. F. Whiteaves; The Utica terrane in Canada, Henry M. Ami; Notes on Cambrian faunas, G. F. Matthew.

Jour. Cin. Soc. Nat. Hist., Vol. xv, No. 2, contains: The preservation of plants as fossils, Jos. F. James; Some new species and new structural parts of fossils, S. A. Miller and Chas. Faber; Manual of the paleontology of the Cincinnati group, Jos. F. James.

Geological Magazine, *Sept.*: Notes on Russian geology, W. F. Hume; The mammoth and the glacial drift, H. H. Howorth; On rapid elevation of submerged lands and the possible results, E. Hill; The so-called serpentines of Lleyn, Catherine A. Raisin.

Oct.: Further additions to Australian fossil Echinoidea, J. W. Gregory; On Liassic sections near Bridport, J. Francis Walker; Further remarks on the Coniston limestone, J. E. Marr; Note on a granite junction in the Ross of Mull, J. G. Goodchild; The Malvern crystallines, A. Irving.

Novem. Further contributions to the Devonian fish fauna of Canada, A. S. Woodward; On porphyritic quartz in basic igneous rocks, A. Harker; Lithophysæ in obsidian, Lipari, H. J. Johnston-Lavis; Faulting in drift, T. Mellard Reade; Glacial geology, Old and New, Percy F. Kendall; Selenology, S. E. Peal; The mammoth and the glacial drift, a reply to A. J. Jukes-Browne, H. H. Howorth.

Am. Jour. Sci., *Sept.* The Gulf of Mexico, as a measure of Isostacy, W. J. McGee; Kelauea in April, 1892, S. E. Bishop; The Devonian system of eastern Pennsylvania, C. S. Prosser; Relations of the Laurentian and Huronian on the north side of lake Huron, A. E. Barlow; Note on the change of electric conductivity observed in rock magmas of different composition on passing from liquid to solid, Carl Barus and J. P. Iddings; Estimation and dehydration of silver oxide, M. Carey Lea.

Oct. An ottrelite bearing phase of a metamorphic conglomerate in the Green Mountains, C. L. Whittle; Mica peridotite from Kentucky, J. S. Diller; Glaciation in the finger-lake region of New York, D. F. Lincoln; Crystallography of the Cæsium-mercuric halides, S. L. Penfield; Restorations of Clavsaurus and Ceratosaurus, O. C. Marsh; Restoration of Mastodon americanus *Cuv.*, O. C. Marsh.

Novem. Unity of the glacial epoch, G. F. Wright; Contributions to mineralogy, No. 54, F. A. Genth, with crystallographic notes by S. L. Penfield; Notes on the Farmington, Washington county, Kansas, meteorite, H. L. Preston; A note on the Cretaceous of northwestern Montana, H. A. Wood; The deep artesian boring at Galveston, Texas, R. T. Hill; Notice of a new Lower Oriskany fauna in Columbia county, New York, C. E. Beecher, with an annotated list of fossils, by J. M. Clarke; Description of the Mt. Joy meteorite, E. E. Howell.

IV. Excerpts and Individual Publications.

The post-Laramie beds of Middle Park, Colo. Whitman Cross, Proc. Col. Sci. Soc., Oct., 1892.

Notes on some eruptive rocks from Alaska. Geo. H. Williams, Nat. Geog. Mag., Vol. IV.

The Vailan or annular theory. Stephen Bowers, Ventura, 8vo, pp. 24, 1892.

V. Foreign Publications.

Scientific Proceedings of the Royal Dublin Society, Vol. VII (n. s.), March, 1892, Part 3, contains: On the structure and origin of the Quartzite rocks in the neighborhood of Dublin. W. J. Sollas.

The fossil Crinoidea in the British Museum (an attempt to put into practice modern ideas of museum arrangement), F. A. Bather. From the annual report of the Museums Association for 1891.

On the discovery of mammoth and other remains in Endsleigh street (London). Henry Hicks. From the Quart. Jour. Geol. Soc., Vol. XLVIII, p. 453, 1892.

Soc. Geog. du Nord. Annales XIX, 1891, contains: Notice preliminaire sur la nature et l'origine des phosphates de chaux de la craie. Renard et Cornet; Observations au sujet de la note sur le terrain houiller du Boulonnais de M. Olry, par M. Gosselet; Composition de l'étage houiller en Bas-Boulonnais, par M. Ludovic Breton; Note sur la decouverte d'une faune marine dans les sables landeniens par M. Gosselet; Apercu sur les gites de phosphate de chaux de Hesbaye d'après les travaux de MM. Lohest, Schmitz et Forir, par M. Gosselet; Sur les terrains phosphatés de Picardie, par Henri Lasne; Observations sur le terrain Silurien des environs de Barcelone, par Charles Barrois; De quelques théories nouvelles, par M. Peroche; Les Insectes des couches triasiques de Fairplay, Colorado. Analyse d' un travail de M. S. Scudder, par M. Charles Maurice; Sur l' existence d' un gisement de Blende et de Galène dans le départment du Nord, par L. Cayeux; Etudes micrographiques du tuffeau à Cyprina planata du Nord de la France et de la Belgique; Du rôle Diatomées dans la formation de ce Tuffeau (notice préliminaire), par M. L. Cayeux; La Craie du Nord de la France et la boue à Globigérines (note preliminaire) par M. L. Cayeux; De l'existence des Diatomées dans l'yprésien du Nord, par M. L. Cayeux; Diffusion des trois formes distinctes de l' oxyde de titane dans le Crétacé du Nord de la France, par L. Cayeux; Memoire sur la faune du grès Amoricain, par Charles Barrois; La

Craie du Nord est bien un dépôt terrigène, par M. L. Cayeux; Sur un calcaire moderne concretionné avec diatomées de Saint-Nectaire-le-Bas, par M. L. Cayeux; Composition minéralogique des Sables glauconieux landeiens, par L. Cayeux; Note sur le Tertiaire du Boulonnais, par H. Parent; Sepulture de l' âge de la Pierre polie à Rouvroy (Aisne) près Saint Quetin, par M. Rabelle; De l'existence de nombreux Radiolaires dans le Jurassique et dans l' Eocene du Nord de la France.—Origine probable de la silice de la Gaize et des Tuffeaux eocenes, par M. L. Cayeux; Sur la presence de vertébrés dans l'Eocene inférieur du Nord de la France, par A. Malaquin; Observation au sujet du mode de formation du conglomerat à silex par M. Gosselet; Du rôle de la geologie dans l' enseignement de le géographie et de l' agriculture, par M. Gosselet; Notes pour l' étude du terrain quaternaire en Hesbaye au Mont de la Trinité et dans les collines de la Flandre, par M. Ladrière.

CORRESPONDENCE.

The Third Texas report.—Permit me to correct a few errors of statement in the review of the Third Annual Report of the Geological Survey of Texas, published in your November number, inasmuch as they put on record Prof. Alpheus Hyatt and myself in a manner unauthorized by us.

You state that Mr. Jules Marcou's determination of the Jurassic age of the Tucumcari beds in New Mexico has been sustained by Capt. C. E. Dutton, Prof. A. Hyatt, and Prof. Robt. T. Hill, and opposed by Prof. Jas. Hall and Dr. J. S. Newberry. I am sure that neither Capt. Dutton, Prof. Hyatt nor myself has authorized this statement. Capt. Dutton has never published a line on the Tucumcari region, and I think has never visited it. In his admirable monograph on Mount Taylor and the Zuni Plateau, he does uphold Prof. Marcou's determination of the Jurassic in New Mexico, but in an en-entirely different portion of the territory from Tucumcari.

Prof. Hyatt and I have studied the region minutely; the former spent a whole field season in the vicinity, while I have made two special trips to this inaccessible locality. By agreement we have refrained from publishing the lengthy papers either might have prepared, and I am positive Prof. Hyatt never recorded an opinion on Tucumcari, but is cautiously working up his material.

I have expressed my opinions in the following five publications.

1. Circular, School of Geology of University of Texas, Austin, 1887.

2. Geological Survey of Arkansas, Annual Report 1888, Vol. II.

3. The Comanche Series of the Texas-Arkansas Region. Bulletin of the Geological Society of America, Vol. II, pp. 503-528, 1891.

4. Notes on the Texas-New Mexican Region. Bull. Geolog. Soc. Am., Vol. III, 1891.

5. On the Occurrence of Artesian and Underground Waters in Texas, New Mexico, etc. Washington, April, 1892.

In the earlier of these writings I said Mr. Marcou had not been properly understood, and his Gryphæa dilatata and Ostrea marshii beds were Jurassic, as he was justified in affirming from the occurrence of these species. But as a result of later investigations and the discovery of these species associated with Comanche faunas, this statement was corrected and in the report upon underground waters, above mentioned, p, 129, which was sent to the GEOLOGIST some months before, Mr. Cummins' report was published, my conclusions upon the geology of Tucumcari were distinctly stated as follows:

THE TRINITY SANDS AND RED BED REGIONS.

"The writer has twice visited the Mesa Tucumcari and found it a most interesting geological remnant of the former area of the Llano Estacado. The table or summit described by Capt. Simpson is covered with the typical Llano Estacado formation, identical in composition and formerly continuous with the sheet which covers the Llano proper, some 20 miles distant. Below this is a vertical escarpment of 50 feet or more of typical Dakota sandstone, resting upon loose sands and clays, forming a slope identical in aspect and fossil remains with the Denison beds of the Washita Division, which have been eroded away from the 400 miles intervening between it and the main body of those beds at Denison, Tex. Beneath this is a large deposit of the typical Trinity sands country, of white pack-sands, thin clay seams, and flagstones, while the base is composed of the typical vermilion sandy clays of the Red Beds."

Since much of this Texas report was used without credit upon work done by myself or my assistants, including Mr. Taff, working under my direction [First Annual Report 1889, pp. LXXXVIII and 106-141] the state geologist, with the above passage before him, might have spared himself the labor of disproving a theory I had long since publicly disowned.

Concerning the age of the Trinity beds of my Trinity division, for which Mr. Taff, without statement of authority or reason, substitutes the name Bosque, I have always held that they present a Wealden fauna which both in Europe and in this country presents certain transitional Jura-Cretaceous features, but is by general agreement placed in the Cretaceous and so considered. If Messrs. Cummins and Taff can speak with positiveness on this subject, they are to be congratulated, for there are several geologists who have had much longer acquaintance with the occurrence and problems of the basal Cretaceous in this country, who, after careful years of labor, are still conservative in expression—among these are Profs. Ward, Fontaine, White, McGee and myself.

Your statement on p. 314, that the Glen Rose beds were not associated by me with the Trinity, but were retained in the Fredricksburg division, is a mistake. This was true in my earlier publications, but in my later papers, especially one upon the Comanche series of the Arkansas-Texas region, read before the Geological Society of America, in Washington 1891, and published by the society, I separated the lower beds of the Comanche series from the Fredricksburg division, and placed the Trinity sands and Glen Rose beds in a distinct division, to which I gave the name of Trinity division. The state geologist of Texas participated in the discussion which followed the reading of this paper [See Bul. Geol. Soc. Amer. Vol. II, p. 327] and inasmuch as the section there published is reproduced by Mr. Taff without a word of credit, except for horizons, I append it in parallel columns with his.

Section and Nomenclature of the Comanche Series as published by Hill in the Bulletin of the Geological Society of America, May, 1891.	*Section and Nomenclature of the Comanche Series as published by J. A. Taff, Third Annual Report Geological Survey of Texas, Sept. 1892.*
DEFINITION OF THE TERRANES.	I. LOWER CRETACEOUS.
CONSTITUTION OF THE COMANCHE SERIES.	
C. The Washita, or Indian Territory Division.	Washita Division.
	m. Vola limestone (3).
	l. Arietina clay.
11. The Denison Beds.	k. Denison (3).
10. The Fort Worth Limestone.	j. Fort Worth (3).
9. The Duck Creek Chalk.	
8. The Kiamitia Clays or *Schloenbachia* Beds.	
B. The Fredericksburg or Comanche Peak Division.	Fredericksburg Division (2).
	i. Kiamitia clay (3).
	h. Austin marble (3).
7. The Goodland Limestone.	g. Flag limestone (3).
6. The *Caprina* Limestone.	f. Caprina limestone (1).
5. The Comanche Peak Chalk.	e. Comanche Peak (1).
4. The *Gryphæa* Rock and Walnut Clays.	d. Texana.
3. The Paluxy Sands.	
A. The Trinity Division.	Bosque Division (5).
	c. Paluxy sand (3).
2. The Glen Rose or alternating beds.	b. Glen Rose (alternating) bed (3).
1. The Trinity or Basal Sands.	a. Trinity sand (3).*

*(1) B. F. Shumard, (2) Dr. Ferd. Rœmer, (3) R. T. Hill.

Why, after the general section had long been published, Mr. Taff, my former assistant, should publish the arrangement of this section and its description as original, with no other credit given than the nomenclature of the above given horizons, may be attributed to the early attempt of an able young worker at publication, but his substitution of "Bosque" for my Trinity Division, [See Bull. Geol. Soc. Amer. 1891, pp. 503-5-28] and his accrediting to Dr. Ferd. Roemer my Fredericksburg division is remarkable.

I am always glad to correct any errors in my work, and I have sometimes amended my nomenclature. Both of these privileges every worker, especially one in a progressive science, has, but it is doubtful if others can change an established nomenclature without explanation.

In the nomenclature of the Comanche and Upper Cretaceous, in my later papers, I have sought to substitute geographic for paleontologic designations of beds, but have aimed to give credit to the humblest assistant. I ask that the readers of Messrs. Cummins' and Taff's papers compare them with my report in the First Annual Report of the Texas Geological Survey, pp. LXXXIII-LXXXVIII and pp. 106-141; with the American Journal of Science, April, 1887, and other papers of mine referred to in this communication.

The valuable writings of Dr. C. A. White, as well as those of Prof. Jules Marcou (who made the first correct determination of the Lower Cretaceous age of the beds of northern Texas), are likewise entirely ignored in this report.*

There are also several erroneous statements in the review concerning the range of species, but these will be reserved for future comment. ROBT. T. HILL.

Washington, D. C., Nov. 18. 1892.

VOLCANIC DUST IN KANSAS AND INDIAN TERRITORY.—The peculiar volcanic dust or sand mentioned by professor Todd in the November GEOLOGIST occurs, as is well known, in various places in western Kansas. I found it, as early as 1874, in Norton county, and professor St. John records it from several localities in the extreme southwestern part of the state. During the past year I have received specimens from the Indian Territory, south of Arkansas City, and from a few miles southwest of Galena, a locality considerably further east than Omaha. The sand in both these latter localities is rather more grayish in color than that from the northwest, but otherwise is identical. The gentleman who gave me the specimen at Galena, stated that the deposit is many feet in thickness at this locality. S. W. WILLISTON.

Lawrence, Kansas, Nov. 22, 1892.

CLASSIFICATION OF THE CEPHALOPODA. The November number of the AMERICAN GEOLOGIST contains a note (p. 327) on the comparison Tables of Classification issued in the July number of *Proc. Geol. Assoc. London*, to illustrate the Presidential address. I do not wonder at your saying "Bather's is the most remarkable mainly on account of its brevity." As you have further reprinted the words that purport to represent my classification, I should like to have the opportunity of saying that I am not responsible for that Table, and that it does not properly represent any views held by me now or formerly. Though no actual classification of the Cephalopoda was ever published by me, still the *cancelled* Table did represent the views held by me in 1888 and expressed in various papers about that date. The views to which I was led were largely influenced by the ideas of American writers, and I should be sorry to see a misleading account of those views disseminated, without correction, by an American publication. Therefore I ask you to be good enough to print the accompanying table. Not having been able to read all the recent literature on Cephalopoda, I cannot say that I regard these as the best possible views at the present day; but I regarded them as the best views pos-

*For a resumé of Mr. Marcou's early determination of the Lower Cretaceous in the Texas region, see Bulletin 45, U. S. Geological Survey; The Present Condition of Knowledge of the Geology of Texas. By Robt. T. Hill.

sible in 1888, and am not aware that any facts recently brought to light would greatly affect them.

Faithfully yours, F. A. Bather.

Natural History Museum,
London, S. W., Nov. 18, 1892.

CLASSIFICATION OF CEPHALOPODA.

LIPOPROTOCONCHIA.		SOSIPROTOCONCHIA.	
Nautiloidea.	**Intermediate and more ancestral forms—**	Ammonoidea.	Coleoidea.
Orthoceratidae (s. str.)	Endoceratidae	Bactritidae	**Osteophora**
Gomphoceratidae	Actinoceratidae	**Asellate Latisellate, and Angustisellate** grades of **Goniatites**	Aulacoceratidae
Poterioceratidae		Families of **Ammonites** uncertain.	Xiphoteuthidae
Ascoceratidae			Belemnitidae
Cyrtoceratidae			Belopteridae
Lituitidae			Spirulidae
Trochoceratidae			Sepiadae
Nautilidae			**Chondrophora**
			(Myopsid)
			Beloteuthidae
			Teuthidae
			Belemnoteuthidae
			Loligidae
			Sepiolidae
			(Oigopsid)
			Octopodidae
			Philonexidae
			Cirrhoteuthidae

The Movements of Muir Glacier.—In accounting for the apparent discrepancy between Prof. Reid's measurements of the movement of the Muir glacier and my own, in your notice of his important work, attention should have been called to one other point, namely, that we did not measure the same portions of the glacier. Professor Reid measured the motion only as far out from the edges as he could plant stakes; but there was a quarter of a mile or more in the middle which he found it impossible to reach. The reason why he could not reach it was that that was the most rapidly moving part where consequently the crevasses were impassable. My base-line was on a level with the edge of the ice, so that we could recognize the pinnacles and domes and moraine-covered patches as they slowly moved past across the horizon. Mr. Baldwin and myself were very confident that we made no mistake in the recognition of these objects. Professor Reid's base-line was several hundred feet higher up upon the mountain side than our line, so that in looking down upon the glacier he had not the same advantages for recognizing the pinnacles. Of course, a larger margin of error should be allowed for our observations than for his, since our angles were taken with a sextant and his with a theodolite. But on points nearer the shore our results were very nearly the same as his. Professor Reid has just returned from another expedition to the Muir glacier, and reports great changes in the appearance of the front. This year the front has assumed almost exactly the shape which is shown in my photographs of six years ago, while two years ago the contour of the front was entirely different. Professor Reid has brought back a large amount of important information about the whole system, but it is too early yet to publish the result.

Oberlin, O., Nov. 7, 1892. G. Frederick Wright.

PERSONAL AND SCIENTIFIC NEWS.

Dr. A. Osann, for many years first assistant to Prof. Rosenbusch in Heidelberg, and later extraordinary professor of mineralogy and petrography in that University, has been appointed geologist on the Geological Survey of Texas and will have charge of the petrographic work of the survey. He sailed from Germany about the middle of November.

A Large Diamond.—The second largest diamond in the world is now undergoing the cutting process at Antwerp. Its weight is at present 474 carats, but it will lose no less than 274 carats before it is ready for the market. Even then, however, it will be the second largest diamond in the world, standing between the 280 carats of the Persian diamond "Great Mogul," whose existence is considered very mythical to-day, and is said to weigh 193 carats, and the Victoria, or Imperial, diamond, the property of the Nizam of Hyderabad, and the Russian "Orloff" brilliant. The De Beers Yellow weighs 225 carats, recently sold to an Indian rajah. Roughly speaking, the Antwerp stone will be about the size of a pigeon's egg. In its present state it measures 2.741 inches by 1.767 inches. Its polished surface will measure .786 inch each way.

Cheap Aluminum.—A French electro-metallurgical company, which employs the Herault-Kiliani aluminum process, asserts that it will be able to sell the aluminum at a price equivalent to less than 15 cents a pound, provided it is in a position to dispose of a yearly output of 3,000 tons of the metal.

Alabama Beryl.—The range of metamorphic schists and coarse granites that traverse Coosa county, Ala., yield some interesting minerals. Among them are tantalite, cassiterite and beryl. Some fine specimens of the latter have been cut for exhibition at the Alabama State Fair soon to be held in Birmingham. The better specimens are found near the old town of Rockford in the vicinity of Hissop P. O.

The most striking geological feature of the district is the occurrence of heavy bands of a coarse schist in places heavily impregnated with graphite and pyrite and lying between extensive ledges of granite. Some large pieces of tantalite have been found near Rockford, the largest weighing 45 ounces, being now in the Museum of the Alabama Geological Survey. Tin ore also occurs, but, so far, only surface fragments and crystals have been found.

The Geological Society of America will hold its fifth annual meeting at Ottawa, beginning Wednesday, Dec. 28, at 10 o'clock a. m. The invitation to this city was issued jointly by the Logan Club, the Canadian Geological Survey, and the Royal Society of Canada, and the sessions will be in the House of Commons building. His Excellency, the Governor-General, will give an address of welcome.

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